3.0 Affected Environment

This chapter provides information on the physical, biological, chemical, social, and infrastructure characteristics of the environment that could be affected by the proposed action and alternatives discussed in this EIS. This information is necessary to evaluate individual and interactive impacts that could result from the activities described in Chapter 2.0. Impacts are discussed in Chapter 4.0.

For the purposes of this EIS, the affected environment encompasses the Moab site, the three alternative off-site disposal locations (Klondike Flats, Crescent Junction, and White Mesa Mill), the transportation (rail and truck) and slurry pipeline corridors leading to the off-site disposal locations, and the borrow areas that may provide borrow materials for the proposed action. Where appropriate, a specific region of influence has been defined. The region of influence is the area that could be affected by activities associated with each alternative; this region varies depending upon the aspect being assessed. Section 3.1 describes the affected environment of the Moab site. Sections 3.2 through 3.4 describe the affected environment of the three alternative off-site disposal locations.

Although both the Klondike Flats and Crescent Junction sites are located north of the Moab site, some environmental, cultural, and social aspects at these alternative sites have important differences; these differences are discussed for each site. When resources and aspects are the same as or similar to those discussed under the Moab site description, the appropriate section under the Moab site is referenced when the resources are first discussed, or a brief summary of the resources is provided at the beginning of the section on alternative disposal sites.

The slurry pipeline route is discussed in the appropriate major section. For example, the pipeline route segments north of the Moab site are described in Section 3.2, Klondike Flats site, or Section 3.3, Crescent Junction site. The pipeline route segments south of the Moab site are discussed in Section 3.4, White Mesa Mill site.

Borrow areas are described in Section 3.5. Many borrow areas are within or near the boundary of a proposed disposal site; because of this proximity, either the general resources present at the borrow area are summarized, or a specific resource section is referenced. More detailed site-specific information could be researched and evaluated once specific borrow sources were selected.

3.1 Moab Site

The Moab millsite lies in eastern Utah in an area characterized by low precipitation, high summer temperatures, and moderate winter temperatures. Unique desert scenery in this area has attracted increasing numbers of tourists and new residents who like the moderate climate and variety of outdoor activities readily available. The focal point for the area is the city of Moab, which is about 3 miles southeast of the millsite on the opposite side of the Colorado River. Much of the surrounding area is open country administered by federal agencies, primarily BLM and NPS.

3.1.1 Geology

The Moab site is at the northwest end of Moab-Spanish Valley along the axis of the Moab Valley salt-cored anticline (Figure 3–1). The northwest part of the valley is Moab Valley; the site is located at the mouth of Moab Canyon. The steep slope southwest of the site flanking Moab Valley rises 1,200 to 1,400 ft to the top of sandstone-capped Poison Spider Mesa. Just north of the site, north of US-191, and at the north end of Moab Valley is a steep slope rising approximately 600 ft that is composed of highly fractured and faulted sandstones.

3.1.1.1 Stratigraphy

Rocks exposed and in subcrop in the area range in age from Middle Pennsylvanian to Middle Jurassic. These bedrock formations and their ranges of thickness are shown in Figure 3–2. This section briefly describes the geologic formations in relation to the site. More detailed geologic descriptions are provided by Doelling et al. (2002) and are summarized in the SOWP (DOE 2003).

Bedrock Formations

The Paradox Formation was deposited in a periodically restricted part of the Paradox Basin. However, no outcrops of Paradox Formation are present in the immediate site area. No boreholes are known to have penetrated the Paradox Formation beneath the site.

The Honaker Trail Formation crops out as ledges on a steep slope west and south of the tailings pile. Up to 600 ft of Cutler Formation is exposed south and west of the site.

The Moenkopi Formation, also west of the tailings pile, consists of mostly red interbedded siltstone, fine-grained sandstone, and mudstone.

Outcrops of the Chinle Formation are located south of the tailings pile.

The Wingate Sandstone forms a prominent gray-pink to red-brown smooth cliff south and west of the tailings pile and forms a wall along the northeast side of Moab Valley and at the mouth of Courthouse Wash. The Wingate is faulted and highly fractured near the Moab anticlinal axis as it plunges southeastward into Moab Valley.

The Kayenta Formation caps Poison Spider Mesa to the south; north of the site, the formation crops out along the edge of Moab Valley near the mouth of Courthouse Wash.

Exposed at the site north of US-191, the Navajo Sandstone forms the northwest end of Moab Valley and dips moderately (about 50 degrees) southwest along the southwest flank of the Moab anticline.

One member of the Carmel Formation and one member of the Entrada Sandstone are present in the northwest end of the site area in the subsurface just north of the Moab Fault (Figure 3–3) in the lower end of Moab Canyon. The Dewey Bridge Member of the Carmel Formation overlies the Navajo Sandstone. The Slick Rock Member, which is the only member of the Entrada Sandstone in the vicinity of the site, is well-fractured in the subsurface along the Moab Fault zone.

Quaternary Deposits

Except for the alluvial deposits, most Quaternary deposits are relatively thin. Because of the subsidence caused by removal of salt from the underlying Moab Valley salt-cored anticline, alluvium deposited mainly from the ancestral Colorado River has accumulated to a thickness of 450 to 500 ft beneath the site in Moab Valley. The subsiding Moab Valley has acted as a sump to catch Colorado River alluvium for much of Pleistocene time since erosion has begun "opening up" the Moab Valley salt-cored anticline and exposing the salt to dissolution by ground and surface waters.

The thick valley-fill alluvial deposits consist mainly of coarse gravelly sand, with minor silt and clay. Boulders as large as 1 to 2 ft in diameter, composed of resistant igneous and metamorphic rock types representing the upper Colorado River drainage, are common in the alluvium. At the mouth of Moab Canyon, the Colorado River alluvial deposits are mixed with and interlayered with generally fine-grained alluvium and detritus that has traveled down Moab Wash. Overlying the coarse alluvial deposits in the immediate site area in Moab Valley adjacent to the Colorado River is finer-grained alluvium of Holocene age composed mainly of sand, silt, clay, and minor lenses of gravel; this modern alluvium of the Colorado River covers much of the site area outside the tailings pile and is approximately 20 ft thick.

3.1.1.2 Structure

The Moab site is in the northern part of the ancestral Paradox Basin (see Figure 3–1). The salts deposited in this basin flowed toward northwest-striking faults in the basin floor, where they became thicker and formed northwest-striking elongate salt diapirs. Basins, called rim synclines, formed between the salt diapirs. Regional compression in Late Cretaceous to early Tertiary time formed broad northwest-striking anticlines and synclines, resulting in the Moab Valley salt-cored anticline (where the Moab site is located), the Courthouse syncline to the northeast of the site, and the Kings Bottom syncline to the southwest (see Figure 3–3). The northwest-striking Moab Fault (Figure 3–3) formed near the crest of the Moab Valley salt-cored anticline in mid-Tertiary time during a period of extensional faulting after regional compression.

Late Tertiary erosion allowed ground water to locally reach the upper parts of the salt diapirs through fractures and joints in the anticlinal folds. The resulting dissolution during late Tertiary and Quaternary time (and to the present) caused local areas of collapse, tilting, faulting, and subsidence of the overlying strata along the salt-cored anticlines. The degree of breaching (or opening up) of the salt-cored anticlines in this part of the Colorado Plateau largely reflects the amount of ground water that has been available for dissolution of the underlying salt and subsequent collapse. Ground water dissolves the salt and carries it away, leaving the insoluble part of the Paradox Formation as residue, called cap rock, on top of the leached salt diapirs.

3.1.1.3 Geologic Resources

In the site area, potash- and magnesium-bearing sylvite and carnallite are probably present in the salt wall, estimated to be at least 9,000 ft high and composed of the Paradox Formation in Moab Valley and adjacent Spanish Valley (Doelling et al. 2002). Similar deposits about 8 miles southeast of the site on the Cane Creek anticline (Figure 3–3) have been commercially extracted. Information is not sufficient to assess the extractability or value of the saline deposits.

Brine has also been produced from salt beds in the Paradox Formation about 2.5 miles southeast of the site. No oil or gas resources are known to exist beneath the site on the basis of oil and gas test holes drilled within 1 mile of the site.

The modern and older alluvium along the Colorado River, covering much of the site outside the tailings pile, contains sand and gravel suitable for highway and other construction. The considerable thickness of alluvial basin fill (up to 500 ft) beneath the site may also contain significant sand and gravel resources. A sand and gravel pit adjacent to the west edge of the site near the junction of US-191 and SR-279 was used by UDOT for highway construction and maintenance. This pit, UDOT 19076 (McDonald 1999) appears to be inactive.

Uranium and vanadium prospects occur south of SR-279 along the lower slopes of Poison Spider Mesa. No significant uranium-vanadium deposits are known to occur on the site; however, uranium and copper deposits have been identified in the lowermost part of the Chinle Formation about 8 miles northwest of the site.

3.1.1.4 Geologic Hazards

Swelling clay (montmorillonite) is present in the Moenkopi and Chinle Formations along the west edge of the site. These bentonite-derived clays are capable of absorbing large amounts of water, accounting for the shrinking and swelling character of the formations and their derived soils.

Piping and rapid erosion may occur in fine-grained soils and unconsolidated fine-grained sediments at the site along the ephemeral stream channel of Moab Wash. The piping can occur when water from storms flows into permeable, noncohesive layers, removes fine sediments, and exits where the layer reaches the surface (Doelling et al. 2002). The void space created is a “pipe” that promotes accelerated erosion.

Active rock-fall areas are along the top of the slope of Poison Spider Mesa, which have the potential to reach the southwest border of the site.

Seismic and salt dissolution hazards associated with the Moab Fault were evaluated by Woodward-Clyde Federal Services (1996a). These hazards consist of the capability of the fault to rupture the surface of the site, the potential for salt dissolution and collapse at the site, and the potential of a microearthquake trend along the Colorado River.

In the vicinity of the site, the Moab Fault consists of two branches—the main Moab Fault and the west branch of the Moab Fault, which is exposed in places west and southwest of the site on the slopes of Poison Spider Mesa. The inferred trace of the main fault before salt dissolution passes through the site approximately across the northeast corner of the tailings pile (Doelling et al. 2002). No historical macroseismicity has been noted along the Moab Fault, and microseismicity studies have not revealed any earthquakes associated with the fault. The site area is in Uniform Building Code 1, indicating lowest potential for earthquake damage (Doelling et al. 2002). A concentration of seismicity was evaluated in a probabilistic seismic hazard analysis by Woodward-Clyde Federal Services (1996b). On the basis of that analysis, the recommended design-peak horizontal acceleration was 0.18g. For a 10,000-year return period for a strong earthquake, this value provides the level of protection equivalent to the extent practicable as specified in 10 CFR 100, “Reactor Site Criteria.” For these geologic and geophysical reasons, the

Moab Fault system is not a capable fault and does not pose a significant earthquake or surface-rupture threat to the present tailings pile.

Vertical subsidence rates in the northwest end of Moab Valley in the site area provide an estimate of the amount of collapse that could be expected from continued salt dissolution beneath the site. Rates of subsidence evaluated by Woodward-Clyde Federal Services (1996b) yield maximum estimates of 1 to 3 ft over 1,000 years. This deformation is expected to occur as a process of slow incremental displacements over time.

Radiocarbon dating of a wood fragment found deep in Colorado River alluvial deposits on the Moab millsite during monitor well drilling in summer 2002 provides another estimate of subsidence for the site. The carbonized wood fragment was in core from alluvial deposits at a depth of 116.5 ft in the boring for well MOA-435. The fragment was 89.5 ft below the top of gravel deposited by the Colorado River. A radiocarbon date of 45,340 years was determined for this wood fragment. Details of this wood occurrence and its radiocarbon dating are in the SOWP, Appendix D (DOE 2003). On the basis of this radiocarbon dating, a subsidence rate of approximately 2 ft per 1,000 years is indicated for the site; this rate is in the middle of the range (1 to 3 ft per 1,000 years) estimated by Woodward-Clyde Federal Services (1996b).

The rate of incision (downcutting) of the Colorado River where it has cut through sandstone bedrock upstream and downstream from the Moab site is much less than the estimated subsidence rate for the Moab Valley. The incision rate for this area has been estimated as 0.6 ft per 1,000 years by Willis (1992), using a dated volcanic ash bed preserved in a terrace at a known vertical elevation above the Colorado River. These subsidence and incision rates indicate that the tailings pile would become approximately 1.4 ft lower during the next 1,000 years in relation to the Colorado River.

Subsidence refers to the geologic process that is lowering the elevation of the entire tailings pile and the Earth's surface at the Moab site because ground water is dissolving the Paradox Formation salt deposits underlying the Moab-Spanish Valley. The rate of subsidence of the Moab-Spanish Valley is approximately 2 ft per 1,000 years. This gradual downward sinking of the tailings pile is partially offset by the gradual regional uplift of the Colorado Plateau.

River incision refers to the geologic process by which the Colorado River cuts down through the bedrock sandstone outcroppings located upstream and downstream of the Moab site. The rate of river incision in this area has been estimated as 0.6 ft per 1,000 years, much less than the estimated subsidence rate for the Moab Valley.

Over geologic time, the combined processes of subsidence and river incision will change the position of the tailings pile in relation to the underlying ground water and the Colorado River. As for ground water, these processes will eventually cause the bottom of the tailings pile to converge with the underlying ground water at an estimated rate of approximately 1.4 ft per 1,000 years. At this rate, DOE estimates that the tailings in the disposal cell would come into permanent contact with ground water in approximately 7,000 to 10,000 years, assuming the minimum depth to ground water ranges from 5 to 7 ft. As for the Colorado River, these processes will eventually lower the disposal cell by approximately 1.4 ft in relation to the river over the 1,000-year regulatory design period. This would place the 100-year floodplain of the river about 1.4 ft higher on the east toe of the cell, creating a higher probability for flooding over time. This potential impact would be very long term, and the potential hazard would be reduced by the proposed buried riprap diversion wall.

3.1.2 Soils

Surface soils in disturbed areas of the site are predominantly sands mixed with clays, silts, and gravels and are saturated within 16 ft of the surface most of the year (NRC 1999). Remaining native soils surrounding the site are predominantly sands mixed with clays, silts, and gravels and are classified as Nakai fine sandy loams (Table 3–1). Soils include sandy loams to loamy fine sands. Soils are generally deep (depths greater than 36 inches), are well-drained, and have a minimal water-erosion potential, a moderate hazard of blowing potential, and an estimated erosion rate of 3 tons per acre per year. Additional information is available in the *Soil Survey of Grand County, Utah, Central Part* (SCS 1989).

Table 3–1. Properties of the Nakai Soil Type

Soil Name	Taxonomy	Depth (inches)	pH	Salinity (mmho/cm)
Nakai	Coarse-loamy, mixed, mesic Typic Calciorthids	40–>60	7.4–8.4	< 2
Permeability (inches/hour)	**Available Water (percent)**	**Textural Class**	**Clay (percent)**	**Erodibility Factors[a]**
2.0–6.0	10–16	Fine sandy loam to loamy fine sand	10–18	K = 0.28 T = 3 Wind = 3

[a]Erodibility factors: "K," used in the Universal Soil Loss Equation, is an indicator of the susceptibility of a soil to sheet and rill erosion by water. Values range from 0.02 to 0.69; the higher the value, the more susceptible the soil is to sheet and rill erosion. "T" is an estimate of the maximum average annual rate of water or wind erosion in tons per acre per year. Wind erosion factors range from 1 to 8; the lower the value, the more susceptible the soil is to wind erosion.
mmho/cm = millimhos per centimeter.
Source: SCS 1989.

3.1.3 Description of Contaminated Materials at the Moab Site

3.1.3.1 Millsite Contamination

In 2001, DOE began radiometric characterization of soils on the millsite. To date, the area north and northeast of the tailings pile have been assessed. Most of the site has soil contamination exceeding EPA standards for radium-226 except for small areas north of the tailings pile and one larger area northwest of the pile where a borrow pit was excavated and soils were used for pile surcharge (i.e., weight on the pile to squeeze out moisture) and for the interim cover. Shallow contamination was also identified north of US-191 on DOE property extending to the property line with Arches National Park.

Depths of contamination range from 6 to 120 inches. The area outside the tailings pile (i.e., the area of windblown contamination) is estimated to contain 71,000 yd^3 of contaminated soils. Measuring the depth of contamination with surface scanning and downhole logging instruments has inherent uncertainties; experience at other UMTRCA sites suggests that the final volume could exceed the volume characterized by a range of 50 to 100 percent.

Additional data collected also suggest that contamination occurs elsewhere on the site. Preliminary surface scans by DOE show contamination between the railroad and SR-279 and also near the abandoned ore-loading station adjacent to the rail tracks. Preliminary scans also show elevated gamma levels southeast of the tailings pile in the tamarisk. However, statistical sampling performed to minimize cutting of the tamarisk between the property fence and the Colorado River indicates that radium-226 concentrations in the area may not exceed EPA standards. A 1980 survey performed for Atlas Corporation (Ford, Bacon & Davis 1979) suggests that contamination does not extend across SR-279 to the southwest and up the steep hillside. A 1982 aerial survey performed by a DOE contractor (EG&G) did not provide any additional data on millsite contamination.

On the basis of site knowledge and past UMTRCA site experience, DOE estimates that 11.9 million tons (8.9 million yd^3) of contaminated materials exist at the Moab site and vicinity properties. However, on the basis of recent surveys that were not available at the time the draft EIS was developed, DOE has slightly increased its estimate of the volume of contaminated off-pile soil that would be disposed of with the tailings. The increase is less than 1 percent of the total estimated volume of contaminated site material. The revised total estimates remain approximate and could increase again after more detailed site characterization is complete. The estimated volumes presented in the draft EIS represented DOE's best estimate based on information available when the draft EIS was developed. Due to the small cumulative change, the draft EIS estimates have been retained as a constant in the EIS for purposes of assessing and comparing the impacts of each alternative. DOE would use the most current and reliable estimates of the volumes of all contaminated site material in developing the remedial action plan.

Table 3–2 presents a summary of the contaminated materials and quantities present at the Moab site and nearby vicinity properties. On the basis of sampling results, Table 3–3 shows the percentages of tailings by type believed to be present in the Moab tailings pile. Additional investigations confirmed that most of the slimes are located in the center of the pile and are surrounded by sandy tailings.

Table 3–2. Contaminated Material Quantities

Source Material	Volume (yd^3)	Weight (dry short tons)
Uranium mill tailings	7,800,000	10,500,000
Pile surcharge	445,000	600,000
Subpile soil	420,000	566,000
Off-pile contaminated site soils	173,000	234,000
Vicinity property material	29,400	39,700
Total	**8,867,400**	**11,939,700**

Table 3–3. Percent of Tailing Types in the Moab Impoundment

Material	% Passing No. 200 Sieve	Percentage of Total Tailings
Sand	Less than 30	7
Slimey-sands	Greater than 30; less than 50	20
Sandy-slimes	Greater than 50; less than 70	23
Slimes	Greater than 70	49

The tailings pile at the site contains the waste residuals from the milling operation. Milling involved both acid and carbonate processing methods (i.e., circuits). Lime was added to the tailings to neutralize the acid-milled tailings. Chemicals used in the processing, including acids, ammonia, and solvents, are incorporated with the silicate grains. Many other minerals, including sulfates and sulfides, are also present in lesser amounts. It is difficult to determine the residence time of the contaminants, although there is evidence that some exist as siliceous mixtures, and others may exist as sulfides, selenides, molybdates, and uranium minerals. Contaminants are also likely to be adsorbed to minerals, especially iron oxyhydroxides.

Bulk chemical analysis of the tailings solids indicates that high concentrations of ammonia, uranium, and radium-226 are present. The mean radium-226, ammonia (as N), and uranium concentrations for the tailings are 516 pCi/g, 423 milligrams per kilogram (mg/kg), and 84 mg/kg, respectively. The finer grained (slimes and silt) fractions have more radium-226 and uranium but less ammonia as (N) than the sand fraction. Other constituents, including iron, manganese, copper, lead, molybdenum, and vanadium, are present in lesser amounts. The pH values of the tailings are near neutral but have zones of pH values as low as 2.5 and as high as 10. The tailings have a small amount of acid-generating capacity in the form of sulfide minerals. The oxidation-reduction potential is not well defined by existing data, and conditions may vary spatially from relatively oxidizing to relatively reducing.

Mean tailings pore water concentrations for radium-226 and uranium are 61.1 picocuries per liter (pCi/L) and 15.1 mg/L, respectively. The average tailings pore water concentration for ammonia (as N) is 1,100 mg/L. Pore water is a mixture of residual milling fluids and water that infiltrated later into the tailings. The pore water appears to be relatively oxidized, although few data are available to assess oxidation-reduction potential. The pH value of the pore water is near neutral, and the mean TDS concentration is 23,500 mg/L. Values of pH, oxidation state, and availability of soluble minerals in the tailings are the main parameters that affect the composition of pore water. Concentrations of organic constituents used in the mill processing circuit are negligible in the pore water. Concentrations of all constituents are much higher in samples of water collected in a shallow-depth sump fed by pore water extracted from the tailings through wick drains than in any of the pore water samples collected from deeper SRK (2000) wells. Analysis of samples collected from the sump indicate the presence of a salt layer in the upper portion of the pile (DOE 2003).

Two underground septic tanks (size unknown) that supported past operations but are no longer used are located inside the radioactively contaminated portion of the site northeast of the historical warehouse. It is unknown if there are buried leach fields associated with these tanks. Organic contamination in soil and ground water samples was not detected by DOE in an analysis performed as part of the site characterization for the SOWP (DOE 2003).

3.1.4 Air Quality

EPA has established National Ambient Air Water Quality Standards (NAAQS) for sulfur dioxide, nitrogen dioxide, carbon monoxide, ozone, lead, and particulate matter (particles less than 10 micrometers [µm] in aerodynamic diameter, designated PM_{10}) small enough to move easily into the lower respiratory tract. NAAQS are expressed as concentrations of particular pollutants that are not to be exceeded in the ambient or outdoor air to which the general public has access (40 CFR 50.1[e]). Primary NAAQS are designated to protect human health; secondary NAAQS are designated to protect human welfare by safeguarding environmental resources (such as soils, water, plants, and animals) (Table 3–4). Utah has adopted NAAQS as the air quality standards for the state.

Table 3–4. Air Quality Standards

Pollutant	Averaging Period	National and State Ambient Air Quality Standard (µg/m^3)[a]		Allowable Increment for Prevention of Significant Deterioration (PSD)[a] (µg/m^3)	
		Primary	Secondary	Class I	Class II
Sulfur dioxide	Annual	80	–	2	20
	24-hour[b]	365	–	5	91
	3-hour[b]	–	1,300	25	512
Nitrogen dioxide	Annual	100	100	2.5	2.5
Carbon monoxide	8-hour[b]	10,000	–	–	–
	1-hour[b]	40,000	–	–	–
Ozone	1-hour[b]	235	235	–	–
PM_{10}[c]	Annual	50	50	4	17
	24-hour[b]	150	150	8	30
Lead	3-month[d]	1.5	1.5	–	–

[a]µg/m^3 = micrograms per cubic meter; where no value is listed, there is no corresponding standard.
[b]Not to be exceeded more than once per year (for ozone and PM_{10}, on more than 1 day per year on the average over 3 years).
[c]Particulate matter less than 10 µm in diameter.
[d]Calendar quarter.

The air quality in the Moab area is generally good. The current median visual range for the Moab region is about 81 miles (Trijonis 1990). Grand and San Juan Counties are designated as being in attainment with NAAQS for sulfur dioxide, nitrogen dioxide, carbon monoxide, and ozone (40 CFR 81.345). Not enough data are available to support a classification for PM_{10}, so a designation of "unclassifiable" is given for that pollutant (40 CFR 81.345). The PM_{10} data for the Moab region (Table 3–5) show one exceedance during the 4-year period of 1991–1994; an average of one exceedance per year over a 3-year period is allowed. No designation (attainment, nonattainment, or unclassifiable) is published for Utah for lead, although data from Utah metropolitan areas indicate that levels of lead are less than 10 percent of NAAQS (Table 3–4 and Table 3–5). Lead concentrations in the atmosphere have decreased markedly in recent years, largely because of the substitution of unleaded gasoline for leaded gasoline. Monitoring locations in Table 3–5 are those that are closest to the Moab site, including those in Colorado.

Table 3–5. Air Quality in the Moab Region

Pollutant	Monitor location[a]	Year	Averaging period	Maximum (μg/m³)[b]	Annual mean (μg/m³)
Sulfur dioxide	Mesa County, Colorado	1991	3 hours	28	4
	Mesa County, Colorado	1992	3 hours	13	4
	Salt Lake City[c]	1993	3 hours	776	34
	Salt Lake City	1994	3 hours	509	29
	Mesa County, Colorado	1991	24 hours	9	4
	Mesa County, Colorado	1992	24 hours	12	4
	Salt Lake City[c]	1993	24 hours	176	34
Nitrogen dioxide	Salt Lake City	1991	Annual		55
	Salt Lake City	1992	Annual		49
	Provo[c]	1993	Annual		49
	Provo[c]	1994	Annual		45
Carbon monoxide	Grand Junction, Colorado	1991	1 hour	14,375	
	Grand Junction, Colorado	1992	1 hour	13,685	
	Grand Junction, Colorado	1993	1 hour	13,800	
	Grand Junction, Colorado	1994	1 hour	13,340	
	Grand Junction, Colorado	1991	8 hours	8,970	
	Grand Junction, Colorado	1992	8 hours	7,705	
	Grand Junction, Colorado	1993	8 hours	7,935	
	Grand Junction, Colorado	1994	8 hours	8,625	
Ozone	Arches National Park	1991	1 hour	141	
	Arches National Park	1992	1 hour	135	
	Canyonlands National Park[c]	1993	1 hour	147	
	Canyonlands National Park[c]	1994	1 hour	143	
PM_{10}	Moab	1991	24 hours	181[d]	34
	Moab	1992	24 hours	65	33
	Grand Junction, Colorado[c]	1993	24 hours	67	25
	Grand Junction, Colorado[c]	1994	24 hours	63	24
Lead	Salt Lake City	1991	3 months[e]	0.09	
	Salt Lake City	1992	3 months[e]	0.05	
	Salt Lake City	1993	3 months[e]	0.05	
	Salt Lake City	1994	3 months[e]	0.05	

[a] With the exception of PM_{10}, few site-specific data are available for Moab. The following monitor locations provide the closest available data.
[b] μg/m³ = micrograms per cubic meter. Values reported are from the nearest monitoring station.
[c] A different station was used for 1993 because reporting at the previous nearest station had been discontinued. For sulfur dioxide, the 1991 and 1992 values are believed to be more representative of current conditions at Moab than are the more recent values at the more distant station.
[d] One exceedance per year is allowed; the second highest value during 1991 was 111 μg/m³, which is below the 24-hour standard.
[e] Calendar quarter.

In addition to ambient air quality standards, which represent an upper bound for allowable pollutant concentrations, there are standards to prevent the significant deterioration of air quality. The prevention of significant deterioration (PSD) standards differ from the NAAQS in that the NAAQS provide maximum allowable *concentrations* of pollutants, and PSD requirements provide maximum allowable *increases in concentrations* of pollutants for areas in compliance with the NAAQS. PSD standards are, therefore, expressed as allowable *increments* in the atmospheric concentrations of specific pollutants. Allowable PSD increments currently exist for nitrogen dioxide, sulfur dioxide, and PM_{10}. PSD increments are particularly relevant when a major proposed action (involving a new source or a major modification to an existing source) may degrade air quality without exceeding the NAAQS (as would be the case, for example, in an area where the ambient air is very clean). One set of allowable increments exists for Class II areas, which cover most of the United States, and a much more stringent set of allowable increments exists for Class I areas, which are specifically designated areas where the degradation of ambient air quality is severely restricted. Class I areas include certain national parks and monuments, wilderness areas, and other areas as described in 40 CFR 51.166 and 40 CFR 81.400–437. Maximum allowable PSD increments for Class I and Class II areas are given in Table 3–4. The PSD Class I area nearest the Moab site is Arches National Park, immediately to the north of the Moab site and about 1,000 ft from the north edge of the tailings pile. Arches National Park has been designated as a mandatory Class I federal area where visibility is an important value (40 CFR 81.430).

3.1.4.1 Conformity Review

Section 176(c)(1) of the Clean Air Act requires that federal actions conform to applicable state implementation plans for achieving and maintaining the NAAQS for the criteria air pollutants. In 1993, EPA promulgated a rule titled "Determining Conformity of General Federal Actions to State or Federal Implementation Plans," codified at 40 CFR Parts 6, 51, and 93. The rule is intended to ensure that criteria air pollutant emissions and their precursors (e.g., volatile organic compounds and nitrogen oxide) are specifically identified and accounted for in the attainment or maintenance demonstration contained in a state implementation plan. For there to be a conformity, a federal action must not contribute to new violations of air quality standards, increase the frequency or severity of existing violations, or delay timely attainment of standards in the area of concern.

The conformity rule applies to proposed federal actions that would cause emissions of criteria air pollutants above certain levels to occur in locations designated as nonattainment or maintenance areas for the emitted pollutants. Under the rule, an agency must engage in a conformity review process and, depending on the outcome of that review, conduct a conformity determination.

DOE conducted the required conformity review and determined that all the proposed alternative actions would result in emissions of one or more criteria air pollutants. These emissions are described further in the air quality sections of Chapter 4.0. However, because none of the proposed action alternatives (on-site or off-site disposal) would occur in or potentially affect a nonattainment or maintenance area, further conformity determination under the conformity rule is not required.

3.1.5 Climate and Meteorology

The desert climate of Moab is characterized by hot summers and mild to cold winters. Weather data summarized by the Utah Climate Center for the town of Moab are presented in the following discussion (Pope and Brough 1996). January and July are the coldest and hottest months, with their respective average temperatures of about 30 °F and 81 °F. The average annual temperature is about 56 °F. Temperature extremes have ranged from –24 °F in January 1930 to 114 °F in July 1989. Temperatures of 32 °F or lower occur about 130 days a year; approximately 90 percent of those occur during November through March. Temperatures of 90 °F or higher occur about 95 days a year; approximately 25 of those days have temperatures of 100 °F or higher. The effects of temperatures higher than 90 °F on human comfort are somewhat moderated by the low relative humidity, which is typically less than 20 percent during daytime.

Average annual precipitation at Moab is 9 inches. The driest months are February and June, which have average precipitation slightly less than 0.5 inch; the wettest months are October and April, which have average precipitation of about 1.15 and 1.00 inch, respectively. Annual precipitation is greatly exceeded by potential evapotranspiration (about 50 inches annually), potential or pan evaporation (about 60 inches annually), and lake evaporation (about 38 inches annually).

The greatest precipitation amount reported at Moab in a single day was 3.99 inches on September 23, 1896, and the most precipitation in a single month was 6.63 inches in July 1918. In a 7-day period in late August and early September 1969, Moab received 6.25 inches of precipitation (Pope and Brough 1996). These large precipitation amounts are examples of high rainfall that sometimes occur in association with the late summer-early fall southwest monsoon period. For shorter-term precipitation events, the greatest expected 30-minute precipitation in 100 years is about 1.3 inches, and the greatest expected 1-hour precipitation in 100 years is about 1.6 inches (Hershfield 1961).

Snowfall is light and averages only about 10 inches per year, occurring mostly from December through February. The greatest amount of snow recorded in a single day was 33 inches on December 31, 1915; that month also had the highest single-month snowfall of 46 inches (Pope and Brough 1996). These snowfalls are highly unusual; a single snowfall of greater than 6 inches is rare and occurs only about once every 3 years.

Low humidity in the region limits fog occurrences (visibility less than 0.3 mile) to fewer than 10 days per year. Thunderstorms occur about 40 days per year. Hail occurs about 3 days per year.

Prevailing winds in the Moab area are from the west-southwest (Figure 3–4). Wind speeds are less than 1 mile per hour (mph) 75 percent of the time; wind speeds are 1 to 7 mph 95 percent of the time (Figure 3–5). The highest wind speed recorded at Moab was 80 mph (Pope and Brough 1996). One tornado with wind speeds of at least 100 mph would be expected once in about 100,000 years (ANS 1983). Cold air drainage at the Moab site can occur from the northwest under stable conditions, creating a temperature inversion. These inversions typically occur in the winter months of December and January at times when snow covers the valley floor and can persist for several weeks.

3.1.6 Ground Water

3.1.6.1 Hydrostratigraphy

Rush et al. (1982), Weir, Maxfield, and Hart (1983), and Weir, Maxfield, and Zimmerman (1983) grouped the aquifers in the northern part of the Paradox Basin into lower and upper hydrologic systems. The upper ground water system consists of unconsolidated and bedrock formations above the impermeable salt beds of the Paradox Formation. Confining salt beds of the Paradox Formation underlie most of the site and locally contribute to high levels of salinity in the overlying unconsolidated basin-fill aquifer. The lower ground water system includes all the stratigraphic units below the Paradox Formation. Site-related ground water contamination occurs in the unconsolidated basin-fill aquifer in the upper hydrologic system. Water-bearing characteristics of major stratigraphic units from the Paradox Formation and above are presented in Figure 3–6.

3.1.6.2 Ground Water Occurrence

Ground water occurs in the bedrock formations and unconsolidated Quaternary material deposited on the floor of Moab and Spanish Valleys. The Navajo Sandstone, Kayenta Formation, and Wingate Sandstone of the Glen Canyon Group contain the principal bedrock aquifer in the region and locally are present only upgradient at the northern boundary of the site. The Navajo Sandstone of the Glen Canyon aquifer ranges in thickness from 300 to 700 ft (Doelling et al. 2002) and is the shallowest and most permeable formation in the Glen Canyon Group. Wells located 7 to 8 miles southeast of the site produce in excess of 1,000 gpm of high-quality water from the Navajo Sandstone for the city of Moab water supply.

Estimated transmissivity for the Navajo Sandstone ranges from near 0 to 700 ft^2/day, and estimated hydraulic conductivity ranges from 0.4 to 1 ft/day (Blanchard 1990). Specific capacities of two water-supply wells at the entrance to Arches National Park, completed in the Navajo Sandstone, were 1.7 and 14.5 gpm per foot (Blanchard 1990). Average saturated thickness of the gravelly sand that constitutes the unconsolidated basin-fill aquifer is approximately 70 ft (Sumsion 1971). This basin fill material may be as much as 450 to 500 ft thick in Moab Valley.

Most of the fresh water in the basin-fill aquifer enters the site from Moab Wash and along geologic contacts between the alluvium and the Glen Canyon Group bedrock present at the north boundary of the site. The bedrock in this area is highly fractured and faulted from incipient collapse of the Moab anticline caused by dissolution of the underlying Paradox Formation salt core of the anticline.

Ground water elevation of the fresh water in the basin fill alluvium is shown in Figure 3–7. West of the Colorado River, these shallow water-table contours are based on average water elevations measured in 2001 and 2002. Contours east of the Colorado River in the Matheson Wetlands Preserve are based on March 2003 water elevation measurements and indicate ground water flow toward the river. The elevation contours indicate that fresh water entering the site at the northern boundary flows south toward the river over the top of a deeper natural brine zone.

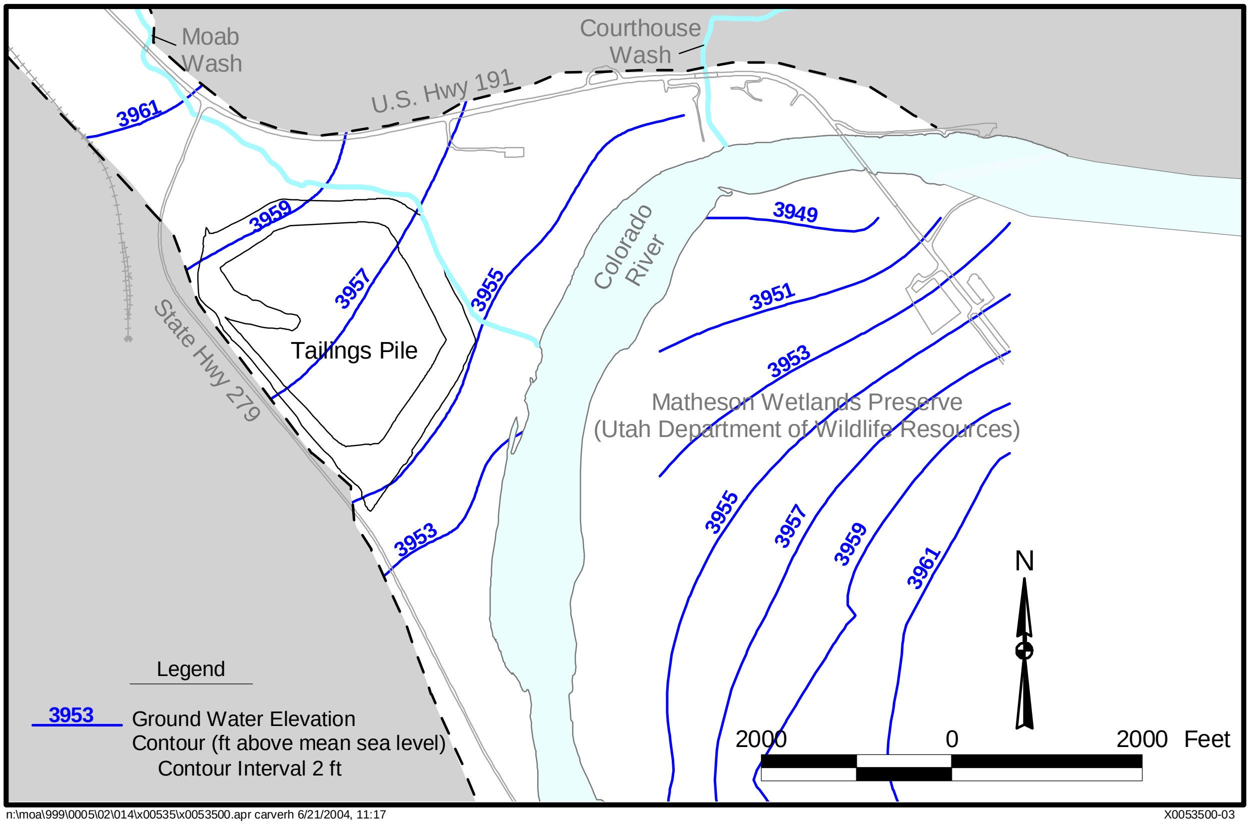

Figure 3–7. Ground Water Elevation Contours on the Upper Freshwater Surface

The deeper brine water results mostly from dissolution of the underlying salt beds of the Paradox Formation present beneath most of the site. Figure 3–8 presents a conceptual model of the subsurface hydrogeology along a representative streamline showing the interface between the deeper saltwater system and the overlying freshwater system. The saltwater interface is defined at the 35,000-mg/L TDS boundary. The transition from the saltwater to the freshwater system occurs over a short vertical distance and is, therefore, referred to as being “sharp.” The vertical position of the interface is in equilibrium because the buoyant force exerted by the brine is balanced by the weight of the overlying fresh water. In natural systems, little, if any, fresh water penetrates salt water at the interface. The fresh water can be thought of as a liquid that “floats” upon a buoyant saltwater liquid. At the Moab site, the interface extends across the site in a wedge shape, in which the deepest part of the interface is near the northwest boundary, and the shallowest depth is near the river. The position of the interface near the river is in dynamic equilibrium and probably shifts laterally and vertically in response to evapotranspiration by the tamarisk plant communities and the stage of the Colorado River. The interface may also shift vertically upward as a result of pumping from the shallow fresh water (e.g., during a pump-and-treat remediation) and cause the salt water to rise to a higher elevation and intrude the fresh water. Saltwater intrusion would result in degradation of the overlying fresh water, which could adversely affect the tamarisk plant communities that are providing some beneficial phytoremediation at the site.

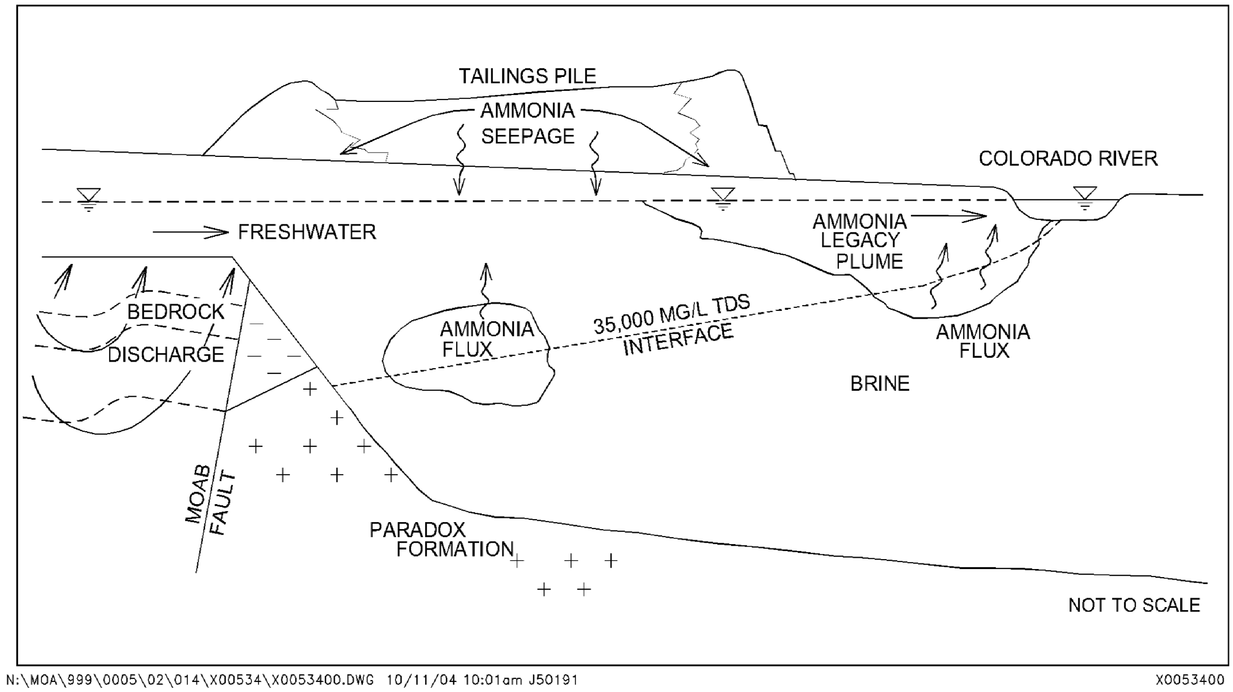

Figure 3–8. Conceptual Model, Saltwater/Freshwater Interface

Rising salt water may also bring higher ammonia and salt concentrations to the surface and cause added contamination flux to the river. Low pumping rates and proper extraction well construction and pump location may prevent saltwater intrusion. Additional information on the hydrogeology of the site is presented in the SOWP (DOE 2003).

Additional recharge to the site occurs through precipitation. The Paradox Formation is believed to be an impermeable boundary (bedrock aquitard) and does not contribute to the site water budget. An estimate of the annual steady-state water budget for each hydrologic component of the system is presented in Table 3–6. Short-term transient effects such as the small positive contribution to bank storage by recharge from the Colorado River during periods of high flow are not included. The estimates are represented with a large range of individual values, and the ranges of the total inflow and total outflow do not overlap, reflecting the uncertainty of the values and suggesting that the true water budget might lie between the two ranges. The SOWP (DOE 2003) provides additional discussion of the ground water hydrology and water budget of the site.

Table 3–6. Estimated Annual Water Budget for the Moab Site

Flow Component	Inflow (gpm)	Outflow (gpm)
Areal Precipitation	16–65	N/A
Moab Wash	0.5–33	N/A
Glen Canyon Group	28–280	N/A
Tailings Pile	20	N/A
Evapotranspiration	N/A	200–500
Colorado River	N/A	300–600
Total	**65–400**	**500–1,100 (rounded)**

N/A = not applicable.

3.1.6.3 Ground Water Quality

The basin-fill aquifer underlying the site is divided into three hydrochemical facies: (1) an upper fresh to moderately saline facies (fresh Quaternary alluvium [Qal]) that has concentrations of TDS up to 10,000 mg/L, (2) an intermediate facies of very saline water (saline Qal), having TDS concentrations between 10,000 and 35,000 mg/L, and (3) a lower briny facies (brine Qal) that has TDS concentrations greater than 35,000 mg/L. All three facies existed beneath the site prior to milling activities. The SOWP (DOE 2003) provides additional discussion of ground water geochemistry and water quality at the site.

A cross-sectional view of contoured TDS concentrations beginning at Moab Wash and extending southeast to the Colorado River is shown in Figure 3–9. The interface between the upper fresh water with the deeper saline water is shown by the 35,000-mg/L contour line. Sixty percent of the alluvial aquifer is contained in the lower briny facies. More than 80 percent of the basin-fill aquifer contains TDS concentrations that are greater than 10,000 mg/L. The upper hydrochemical facies contains limited fresh water with less than 3,000 mg/L TDS that could provide potable water (Figure 3–9). The volume of ground water containing 3,000 mg/L or less TDS represents less than 3 percent of the total volume in the basin-fill aquifer beneath the site. All the fresh water with TDS concentrations less than 3,000 mg/L that could provide potable water occurs upgradient of the tailings pile near Moab Wash. Though some of the TDS in the freshwater system is from recent contamination, the percentage of the aquifer that would return to TDS concentrations of less than 3,000 after remediation would be minimal.

The fresh water quickly becomes mixed with more saline water in the basin-fill aquifer as it enters the site from Moab Wash and flows toward the Colorado River. Salinity naturally increases with depth and distance from the freshwater source contribution from Moab Wash. Mixing of the two background water types (fresh upgradient water with the deeper depth saline water) influences the background water quality at the site. The result is a background water quality in the basin-fill aquifer that is highly variable both vertically and horizontally across the site.

Background conditions in the upper fresh Qal facies are characterized by low concentrations of uranium and other trace metals that are all below the EPA standards in 40 CFR 192 (Table 3–7). TDS concentrations range from 677 to 7,820 mg/L, which classifies the water quality as fresh to slightly saline. Background alkalinity as calcium carbonate ranges from 137 to 189 mg/L. There is no EPA standard for ammonia in 40 CFR 192. Ammonia–N concentrations are less than 1 mg/L. Sulfate concentrations range from 180 to 1,140 mg/L. Calcium concentrations range from 47 to 294 mg/L. Magnesium concentrations range from 31 to 188 mg/L. On average, the pH value of the upper fresh Qal facies is near neutral (7.7), and the redox condition is slightly oxidizing (oxidation-reduction potential is 186 millivolts [mV]).

Table 3–7. Standards for Inorganic Constituents in Ground Water at UMTRCA Sites

Constituent	Standards[a]		Background[a]	
	EPA (40 CFR 192)[b]	SDWA[c]	Fresh Qal Facies Range	Brine Qal Facies Range
Arsenic	0.05	0.01	0.00018–0.0015	0.00015–0.11
Barium	1.0	2.0	0.0222–0.033	0.031–0.121
Cadmium	0.01	0.005	<0.0001–<0.0017	<0.0001–0.014
Chromium	0.05	0.1	<0.0005–<0.011	<0.003–<0.01
Lead	0.05	N/A	<0.0001–<0.0055	0.00054–0.184
Mercury	0.002	0.002	<0.0001–<0.0002	<0.0002–<0.0002
Molybdenum	0.1	N/A	<0.0018–0.01	<0.004–<0.009
Nitrate (as N)	10[d]	10[d]	1.22–15.9	<0.02–0.075
Selenium	0.01	0.05	0.0091–0.0266	<0.0001–0.009
Silver	0.05	N/A	<0.0001–<0.0055	<0.0001–<0.004
Radium (combined radium-226 and radium-228)	5 pCi/L	5 pCi/L	N/A	N/A
Radium-226	N/A	N/A	0.07–0.16 pCi/L	<0.29–9.26 pCi/L
Radium-228	N/A	N/A	<0.5–1 pCi/L	2.6–6.09 pCi/L
Uranium (combined uranium-234 and uranium-238)	0.044[e]	0.03	0.0042–0.0259	0.0007–0.0269
Gross alpha-particle activity (excluding radon and uranium)	15 pCi/L	15 pCi/L	<6.73–<73.92 pCi/L	<356.33–<473.08 pCi/L

[a]Concentrations reported in milligrams per liter (mg/L) unless noted otherwise; pCi/L = picocuries per liter.
[b]Maximum concentration limits, 40 CFR 192, Table 1, Subpart A.
[c]Maximum contaminant levels, Safe Drinking Water Act, 40 CFR 141.23 and 141.62.
[d]Equivalent to 44 mg/L nitrate as NO_3.
[e]Equivalent to 30 pCi/L, assuming secular equilibrium of uranium-234 and uranium-238.
N/A = not applicable

Background conditions in the lower brine Qal facies are characterized by a poor water quality resulting from the dissolution of gypsum and salt beds in the underlying bedrock formations. The water is a sodium-chloride type with TDS concentrations up to 97,000 mg/L, which classifies the water quality as briny. Maximum detected concentrations of arsenic (0.11 mg/L), cadmium (0.014 mg/L), and lead (0.184 mg/L) are all slightly higher than EPA standards in 40 CFR 192. Maximum concentrations of uranium (0.027 mg/L) are less than the EPA standard. Ammonia background concentrations range from 0.03 to 3.0 mg/L. Safe Drinking Water Act secondardy standards are exceeded for sulfate (250 mg/L), chloride (250 mg/L), manganese (0.05 mg/L), and iron (0.3 mg/L), demonstrating the poor quality of the brine Qal background ground water. Secondary standards are unenforceable.

Site-related constituents have contaminated the basin-fill aquifer beneath the tailings pile and beneath the former millsite. Ammonia, nitrate, sulfate, molybdenum, uranium, gross alpha, and gross beta are the site-related constituents most prevalent in the basin-fill aquifer. The relatively low distribution ratios (R_ds) measured for uranium and ammonia explain the higher prevalence of these site-related constituents, which are conserved in the ground water and are more easily dispersed from the source area. Similarly, molybdenum and nitrate are geochemically conservative and tend to be highly mobile in ground water under almost all conditions.

Concentrations of magnesium, cobalt, manganese, and strontium exceed the upper limit of the range in natural background for the fresh Qal facies in more than 50 percent of the samples but do not exceed the upper limit of natural background for the brine Qal facies in any of the samples. Similarly, cadmium and nickel concentrations exceed the upper limit of natural background for the fresh Qal facies in more than 50 percent of the samples but exceed the upper limit in natural background for the brine Qal facies in only 3 percent or less of the samples. This low frequency reflects the relatively high concentrations that occur naturally in the Paradox Formation brine.

Other site-related constituents are present at concentrations above the upper limit of natural background; however, concentrations exceed background less frequently. For example, arsenic concentrations exceed the upper limit in approximately 35 percent of the samples when compared to the fresh Qal background but in only 3 percent of the samples when compared to the brine Qal background. Selenium concentrations exceed the upper limit in approximately 29 percent of the samples when compared to the fresh Qal background and in 54 percent of the samples when compared to the brine Qal background. Vanadium concentrations exceed the upper limit in approximately 19 percent of the samples when compared to the fresh Qal background and in 10 percent of the samples when compared to the brine Qal background. Antimony, barium, chromium, lead, mercury, silver, and zinc concentrations exceed the upper limit of natural background for either the fresh or brine Qal facies in only 10 percent or less of the samples.

Ground water concentration limits for arsenic, barium, cadmium, chromium, lead, mercury, molybdenum, nitrate, selenium, silver, uranium (combined U-234 and U-238), gross alpha (excluding radon and uranium), and radium (combined radium-226 and radium-228) are regulated by EPA standards (see Table 3–7). Of these constituents, the maximum concentrations detected for arsenic, cadmium, uranium, radium, gross alpha, nitrate, selenium, and molybdenum exceed EPA standards. The remaining regulated constituents (barium, chromium, lead, mercury, and silver) are all present at relatively low concentrations below EPA standards.

The areal distribution of uranium concentrations greater than 0.044 mg/L, interpolated and contoured on the upper surface of the ground water, is presented in Figure 3–10. The highest uranium concentrations are in the shallow ground water in the former millsite area. Cross-sectional views of the uranium plume and additional isoconcentration maps of uranium as a function of depth are provided in the SOWP (DOE 2003). SMI (2001) suggested that the high uranium concentrations beneath the millsite are caused by waste leaking from the former wood chip disposal areas. Although the uranium plume is in an area where wood chip disposal was likely to have occurred, lithologic logs of borings installed in this area of the site do not indicate that they penetrated through the wood chip pits. Another possible source of the high uranium concentrations is the uranium ore stockpiles; however, samples collected from monitor wells nearest the largest known ore stockpiles have lower uranium concentrations. Whether the source of the high uranium concentrations in ground water samples is the wood chip pits, the ore stockpiles, or some other millsite-related release, it seems that some of the ground water contamination originates in the millsite area, independently of the tailings pile.

Although ammonia has no EPA standard in 40 CFR 192, it occurs at concentrations significantly greater than natural background, is one of the most prevalent contaminants in the ground water, and is the constituent of greatest ecological concern that is discharging to the Colorado River in backwater areas adjacent to the site. The areal distribution of ammonia concentrations greater than 50 mg/L, interpolated and contoured on the upper surface of the ground water, is presented in Figure 3–11. The highest concentrations in the shallow ground water, greater than 500 mg/L, appear near the downgradient edge of the pile and extend to and discharge to the Colorado River. The highest ammonia concentrations in surface water samples are detected in samples collected closest to the riverbank adjacent to the tailings pile and immediately downstream of Moab Wash. A comparison of ground water data with surface water data shows that, with few exceptions, concentrations of site-related constituents are much lower in the surface water than in the ground water. Ammonia concentrations in the river are approximately 2 orders of magnitude lower than in the ground water. Available data (DOE 2005b) suggest that at least order-of-magnitude decreases in constituent concentrations can be expected as ground water discharges to the river. For further discussions see Section 2.3.1.2. Isolated pools or very shallow areas may be exceptions to this; however, those locations are temporary and are unlikely to represent important aquatic habitat.

Relatively high ammonia concentrations in ground water also occur at depth beneath the tailings pile (Figure 3–12). During milling operations, the tailings pond contained fluids with TDS concentrations ranging from 50,000 to 150,000 mg/L. Because these salinities exceed 35,000 mg/L, they had sufficient density to migrate vertically downward through the freshwater system and into the brine. This downward migration of the tailings pond fluids into the saltwater system is believed to have created a reservoir of ammonia that now resides below the saltwater interface. This ammonia plume below the interface probably came to rest at an elevation where it was buoyed by brine having a similar density. Under present conditions, the ammonia plume beneath the saltwater interface represents a potential long-term source of ammonia to the freshwater system. The conceptual model presented in Figure 3–8 illustrates the ammonia source at the saltwater interface (basal flux), the legacy plume, and seepage of ammonia from tailings pore fluids.

3.1.6.4 Ground Water Use

Historical records indicate that two water supply wells were present at the site before milling operations began in 1956 (DOE 2003). Both wells were located near the northwest area of the tailings pile. Records indicate that the first well, designated as well C, was installed to a depth of 67 ft by the U.S. Department of the Interior Grazing Service in 1940 and provided approximately 20 gpm from the basin-fill aquifer, presumably used for livestock watering. The second well, designated as well B, was installed to a depth of 114 ft by the U.S. Atomic Energy Commission in 1954 just prior to mill construction. The zone of completion for well B is unknown. This well produced approximately 11 gpm through a perforated casing and was presumably used to supply process water for the mill. In both cases, the quality of the water is unknown, and the wells have subsequently been decommissioned. No other water wells are known to have existed at the site prior to milling.

The Navajo Sandstone of the Glen Canyon aquifer, which ranges in thickness from 300 to 700 ft (Doelling et al. 2002), is the shallowest and most permeable formation in the Glen Canyon Group. Consequently, it is the primary target for most bedrock wells drilled in the area (Eisinger and Lowe 1999). The city of Moab derives most of its drinking water from a well field that is completed in the Glen Canyon aquifer near the northeast canyon wall of Spanish Valley (Blanchard 1990). Two water-supply wells located near the entrance to Arches National Park are completed in the Navajo Sandstone.

Numerous springs flow from the Navajo Sandstone. Flux from these springs is limited to less than 10 gpm but is sufficient to provide water for a few cattle (Doelling et al. 2002). Other consolidated formations in the Spanish Valley, such as the Entrada Sandstone, are capable of transmitting and yielding small quantities of water but are not important as a water resource (Sumsion 1971).

Unconsolidated basin-fill deposits make up a secondary aquifer used mostly for irrigation and some domestic water supply in Spanish Valley (Steiger and Susong 1997). More than 200 wells completed in the unconsolidated material in the Moab-Spanish Valley area (Sumsion 1971) range in depth from 30 to 300 ft (Eisinger and Lowe 1999). Water in the unconsolidated aquifer is generally of poorer quality than that of the Glen Canyon and Entrada aquifers. Near the Colorado River, TDS and trace metals concentrations in the basin-fill aquifer increase as a result of dissolution of the underlying Paradox Formation salt beds (Cooper and Severn 1994).

3.1.7 Surface Water

3.1.7.1 Surface Water Resources

The Moab site is located within the Southeast Colorado Watershed Management Unit as designated by UDEQ’s Division of Water Quality (UDEQ 2000). This watershed unit includes the Colorado River in the vicinity of the Moab site and all its tributaries and other water bodies between the Colorado River and the Colorado/Utah state line.

The principal surface water resource in the area, the Colorado River, lies 500 to 700 ft from the easternmost extent of the tailings pile, which is located on alluvial material deposited by the river. It flows south along the east edge of the site, and flows in deeply incised bedrock canyons cut by the river at the northeast and southwest borders of Moab Valley. The Colorado River flows south out of Moab Valley through The Portal, 1,000-ft sandstone cliffs flanking the entrance to the river canyon. The river drains one of the most arid sections of the North American continent. The rugged mountains, broad basins, and high plateaus in the Upper Colorado Basin (above Lees Ferry, Arizona) have been deeply entrenched and dissected (Price and Arnow 1974).

Courthouse Wash empties into the Colorado River 0.5 mile upstream from the tailings pile, and Moab Wash crosses the site along the north and east sides of the tailings pile. The channel of Moab Wash was rerouted east of the mill during operations to mitigate flooding potential during peak flows. Courthouse Wash drains 102 square miles, has an average discharge of 2.12 cfs, and produces peak flows reaching 12,300 cfs. Courthouse and Moab Washes are ephemeral and are dry much of the year. Courthouse Wash sustains flows for longer durations than Moab Wash, which drains an area of only 5 square miles (Smith Technology Corporation 1996). Moab Wash is an ungaged stream.

The Dolores River and the Green River empty into the Colorado River upstream and downstream, respectively, from Moab and the tailings pile. The Scott M. Matheson Wetlands Preserve (Matheson Wetlands Preserve), a shallow wetland open to the public and managed jointly by the Nature Conservancy and the Utah Division of Wildlife Resources (UDWR), is located across the river from the pile.

Natural streamflow of the Colorado River has been affected by many diversions and dams. The dams above the Moab area are not large in comparison to other dams in the Upper Colorado drainage system, such as the Flaming Gorge or Glen Canyon dams. The reservoirs along the Colorado River tributaries upstream of the Moab area store only about 10 percent of the total volume of water stored in Lake Powell (Van Steeter and Pitlick 1998), which is located 150 miles downstream from Moab. However, the presence of these dams has altered streamflow significantly by controlling the extreme high and low flows experienced prior to dam construction. These controlled flows have resulted in changes of river morphology and other characteristics such as sediment load (Van Steeter and Pitlick 1998).

The Cisco, Utah, gaging station (the closest station upstream of the site) is located 1 mile below the confluence of the Colorado and Dolores Rivers, and 31 miles upstream from the Moab site (NRC 1979). The drainage area above the gage is 24,100 square miles. The average discharge for 59 years of record (1911 to 1970) was 7,711 cfs, and maximum and minimum daily mean flows measured 73,200 cfs and 640 cfs, respectively. The complete period of record for the Cisco gaging station extends from January 1895 through 2003. The first 15 years consist of calendar-year rather than water-year discharge statistics. The maximum discharge for the complete period of record was 76,800 cfs.

3.1.7.2 Surface Water Quality

The Colorado River Basin Water Quality Control Project was established in 1960 (U.S. Department of Health, Education, and Welfare [HEW] 1961), and much of the early monitoring of the river was conducted in support of that project. A study conducted to determine the potential effects of the Moab site identified several constituents in the Colorado River in the study area that had concentrations above recommended limits, including sulfate, chloride, TDS, and manganese (HEW 1961). The presence of these constituents was attributed to natural causes. Highest levels of some analytes were detected in samples collected at the confluence of the Dolores River with the Colorado River. Studies of Colorado River water quality were undertaken in 1966 mainly to study the effects, if any, of uranium milling operations on the river. Radionuclides, particularly radium, were of main concern in these studies (HEW 1966).

In the 1970s, much of the focus on the Colorado River Basin concerned salinity control, pursuant to passage of the Colorado River Basin Salinity Control Act (Public Law 93-320). A major source of salinity load to the Colorado River, particularly in the Southeast Colorado Watershed Management Unit, is the Dolores River. As the Dolores River crosses the Paradox Valley in southwestern Colorado, highly saline ground water (brine) discharges to the river (Chafin 2003). The source of the brine is a collapsed salt anticline, similar to that in Moab Valley. Surface waters in the vicinity of the Moab site are influenced by discharge of ground water containing dissolved salts from the Paradox Formation that is found in the cores of salt anticlines characteristic of this region (DOE 2003). Highly saline ground water is known to occur beneath the Moab site as well as at the Matheson Wetlands Preserve across the river from the site. Near the confluence of the Dolores River and the Colorado River, the salinity of the Dolores River limits the use of river water for irrigation of some crops (UDEQ 2000). Onion Creek, another high-salinity tributary to the Colorado River, has been designated as an impaired water body because of elevated levels of TDS from both natural and agricultural sources (UDEQ 2000).

Several other water bodies in the Southeast Colorado Watershed Management Unit have been designated as impaired because of high TDS levels, including Mill Creek, which is a source of recharge to the alluvial aquifer across the Colorado River from the Moab site.

Selenium is also cause for regional concern. Although selenium levels have received greater attention in the Upper Colorado River Basin in Colorado, where concentrations have been detected up to 2 orders of magnitude above the National Ambient Water Quality Criteria of 0.005 mg/L (Spahr et al. 2000), concentrations in the vicinity of the Moab site are also relatively high. Concentrations of other constituents are known to be elevated in the Upper Colorado River Basin and the Southeast Colorado Watershed Management Unit as a result of the extractive industries; these effects tend to be more localized (Spahr et al. 2000; UDEQ 2000).

More recently, surface water monitoring of the Colorado River Basin, which includes the Moab site, has been conducted as required by the Clean Water Act. An intensive monitoring program took place between July 1997 and June 1998 to assess streams against state water quality standards and pollution indicators to determine if their designated beneficial uses were being met (UDEQ 2000).

Water quality of the Colorado River has declined over the years as human activities in the basin have expanded. Dams and water-diversion projects have greatly accelerated water loss through evaporation and consumption, resulting in higher salinities (i.e., higher TDS), altered temperature and flow regimes, and altered nutrient and suspended solids transport (NRC 1999). Industrial development (mining and milling in particular) and rapid urbanization have introduced wastewaters containing a variety of contaminants into the river, including suspended sediments, acid mine drainage, heavy metals, radionuclides, and organic wastes.

Despite the different factors that impair the surface water quality of the Colorado River, the portion of the river belonging to the Southeast Colorado Watershed Management Unit was assessed as fully supporting all its beneficial uses, according to results of the intensive monitoring conducted from July 1997 to June 1998. Therefore, the overall river water quality is considered to be good. Of the 981 stream miles within the Southeast Colorado Watershed Management Unit, 27 sampling sites were used in the assessment. Four of the 27 sampling sites were located on the Colorado River (UDEQ 2000).

3.1.7.3 Site-Related Surface Water Contamination

In addition to previous characterization, DOE conducted a baseline round of surface water sampling in the Colorado River near the site in summer 2002. Analytical results of samples collected adjacent to the site were compared to background concentrations and aquatic benchmarks to develop a list of contaminants of potential concern. The analytical results confirmed that ground water discharge from the Moab site has caused localized degradation of surface water quality. As a result of that evaluation, ammonia, copper, manganese, sulfate, and uranium are considered contaminants of concern.

Additional sampling conducted in 2004 focused on understanding the effects of ground water discharge on surface water quality in backwater areas that may provide preferred habitat for endangered fish. The sampling results (DOE 2005a) confirmed both historical and the 2002 sampling results.

Concentrations of contaminants of potential concern in surface water samples vary widely, depending on sampling locations and river flow conditions. Concentrations are highest immediately adjacent to the riverbank in areas where water is shallow, slow moving, or pooled where it is cut off from the main channel of the river. Concentrations are most likely to be elevated during average to low river stages. The constituents with concentrations that are most consistently elevated in samples from the Colorado River are ammonia and uranium. The highest ammonia concentrations have been detected in samples from areas next to the riverbank immediately downstream of Moab Wash. DOE conducted field mapping of the most distinctive features in the river adjacent to the site in November 2001 (DOE 2003). Those mapped features are shown on Figure 3–13. The distribution of maximum uranium concentrations detected in the surface water samples since 2000 is shown in Figure 3–14. The distribution of maximum ammonia concentrations detected in surface water samples since 2000 is shown in Figure 3–15. However, samples collected in the main river channel show minimal or no impact to water quality. Sampling has shown that concentrations of contaminants decrease to natural background levels within 0.5 mile downstream of the Moab site.

Low river flows expose greater portions of the Moab Wash sandbar, creating increased backwater areas that allow for higher concentrations of ammonia in the surface water. However, a study completed in 2000 (SMI 2001) determined that during high flows, backwater areas are eliminated near the site, and ammonia concentrations near the shore are diluted to protective levels (within EPA's recommended total ammonia protection criteria), or loading is temporarily stopped by river water flowing into the aquifer because of the seasonally high river stage. This finding suggests that snowmelt runoff periods (May and June) may effectively reduce the ammonia concentration in the Colorado River.

Because ground water gradients on both sides flow toward the river, it is likely that the presence of the ground water brine affects surface water quality. However, because process fluids disposed of in the former tailings pond contained some of the same constituents that occur in natural brines, distinguishing between naturally occurring constituents and site-related constituents in surface water is not straightforward. Increases in sodium, chloride, or dissolved solids content of river water (among other constituents) in the vicinity of the site, compared to background concentrations, could be a result of discharge of either site-related contaminated ground water or natural brines.

3.1.7.4 Surface Water Use

The Colorado River Compact of 1922 established water allocations to the Upper and Lower Colorado River Basins, which encompass seven states (Chrisman et al. 1976). The 1944 Treaty with Mexico established a Colorado River water reserve that must cross the international boundary. Glen Canyon Dam defines the point of compliance for water allocations between the Upper and Lower Colorado River Basins. Numerous diversions occur for irrigation. Phoenix and Tucson, Arizona, as well as the Mexican border towns of Mexicali and Tijuana, obtain drinking water from the Colorado River. No discharge occurs into the Gulf of California because the Colorado River is completely diverted by the United States and Mexico.

Surface water consumption from the Colorado River watershed is less than 25 million gallons per day (39 cfs) in Grand County, Utah. This water is used almost exclusively for agricultural irrigation. Industry, mining, and thermoelectric power plant cooling account for less than 10 percent of this consumption. DOE's water right (previously Atlas' water right) allows for 3 cfs consumptive and an additional 3 cfs nonconsumptive (6 cfs total). The Colorado River is not currently used as a drinking water supply for the city of Moab.

Water from the Colorado River was not diverted for use in Moab-Spanish Valley prior to 1971, other than for the Atlas mill (Sumsion 1971). Domestic and public drinking water supplies are obtained from ground water, streams, and springs. In Utah, use of Colorado River water for purposes other than recreation is limited. In Grand County downstream from Moab, water is withdrawn from the river for irrigation of about 100 to 150 acres of hay and small grains, and a water right for consumptive use of 3 cfs is held for operations at Potash. No additional water withdrawals are believed to occur in Utah, including Canyonlands National Park and Lake Powell (NRC 1999). The Colorado River in the vicinity of Moab is used for swimming, rafting, boating, and fishing as well as other forms of recreation and is a recognized scenic waterway. The stretch of the river adjacent to the site is within the area designated as critical habitat for four endangered species of fish. For further details, see Section 3.1.10, "Aquatic Ecology."

3.1.7.5 Surface Water Quality Criteria

Five contaminants of concern in the surface water have been identified, as described in Section 3.1.7.3 (Site-Related Surface Water Contamination) and Appendix A2. There are no EPA surface water standards in 40 CFR 192. However, UMTRCA requires DOE to determine applicable regulations in consultation with the State of Utah. Surface water quality criteria for the protection of aquatic species have been developed in Appendix A2 for these contaminants of concern. The criteria for ammonia and copper are consistent with the standards currently specified in the Utah Administrative Code R317-2. In the case of ammonia, the State of Utah is in the process of updating its standards to be consistent with the current Ambient Water Quality Criteria published by EPA. Suter and Tsao (1996) were used where state and federal standards were not available. There are no federal or State of Utah standards for uranium or sulfate. Suter and Tsao developed estimated lowest chronic uranium values for fish extrapolated from laboratory studies. The lowest chronic value is considered conservative in comparison to results of studies on swim-up fry and juvenile Colorado pikeminnow (*Ptychocheilus lucius*), razorback sucker (*Xyrauchen texanus*), and bonytail (*Gila elegans*) (Hamilton 1995). Sulfate was retained as a contaminant of concern because concentrations are elevated when levels of other contaminants of concern are also elevated. Table 3–8 summarizes the protective criteria for each contaminant of concern.

3.1.8 Floodplains

The 100-year floodplains for Moab Wash and the Colorado River and the 500-year floodplain of the Colorado River occupy more than one-third of the Moab site (Figure 3–16). The Colorado River floodplains extend the length of the eastern site boundary from the river's edge to distances ranging from 500 to 1,200 ft west and are approximately 10 ft above the average river level. The tailings impoundment is located within the 100- and 500-year floodplains of the Colorado River and within the floodplain of the PMF. Two dams upstream of the Moab site affect the flow of the Colorado River: Blue Mesa Dam on the Gunnison River and McPhee Dam on the Dolores River.

Table 3–8. Summary of Surface Water Quality Criteria for Aquatic Species

Contaminant of Concern	Protective Acute Criteria (mg/L)	Protective Chronic Criteria (mg/L)	Source of Criteria
Ammonia	1.5 – 41.7[a]	0.17 – 4.13[b]	NRWQC; EPA 1999[c]
Copper	0.013[d,e]	0.009[d,e]	NRWQC; EPA 2002[f]
Manganese	2.3	1.78	Suter and Tsao 1996
Sulfate	N/A	N/A	No published criteria
Uranium	0.142	0.142	Suter and Tsao 1996

[a]Criteria are pH and life-stage dependent; early life stages are assumed to be present, and salmonids are assumed to be absent; range represents calculated criteria based on measured range of surface water pH values at the Moab site from 2000 to 2002 (Appendix D, SOWP; DOE 2003).
[b]Criteria are pH, temperature, and life-stage dependent; early life stages are assumed to be present and salmonids are assumed to be absent; range of values represents calculated criteria based on measured range of surface water pH values and temperature at the Moab site from 2000 to 2002 (Appendix D, SOWP; DOE 2003).
[c]National Recommended Water Quality Criteria (NRWQC) are based on EPA's ambient water quality criteria (EPA 1999).
[d]Criteria for metals are expressed in terms of dissolved metals in the water column.
[e]Criteria are expressed as a function of hardness (milligrams per liter) in the water column. The value listed corresponds to a hardness of 100 mg/L.
[f]National Recommended Water Quality Criteria are based on EPA's criteria (EPA 2002).
N/A = not available; no published criteria available. Note: measured background sulfate concentrations in the surface water range from 84 to 439 mg/L.

Because of terracing and lack of river access during regular high-flow events (less than 5-year occurrence), the floodplain is not considered an "active" floodplain. Most of the surface has been disturbed in the past by milling and soil borrow operations. Some areas are sparsely vegetated, and other areas are dominated by tamarisk. A small patch of mature cottonwoods exists in the northeastern portion of the site.

Courthouse Wash drains 102 square miles and empties into the Colorado River immediately upstream of the Moab site. Moab Wash, which drains approximately 5 square miles, runs through the middle of the site to the Colorado River.

Appendix F, "Floodplain and Wetlands Assessment and Floodplain Statement of Findings for Remedial Action at the Moab Site," includes a more detailed description of floodplains at the Moab site.

3.1.9 Wetlands

Several areas below the tamarisk next to the Colorado River were investigated in February 2002 and were found to contain wetland plants and soils. Although their boundaries have not been formally delineated, these areas are jurisdictional wetlands. Neither the tamarisk areas nor the vegetated margin of a holding pond for irrigation water qualify as wetlands.

The Matheson Wetlands Preserve, across the river from the Moab site, has a variety of wetland types that include emergent wetlands, shrub wetlands, cottonwood stands, and ponds. This 875-acre preserve contains the only sizable wetland remaining on the Colorado River in Utah. Appendix F includes a more detailed description of wetlands at the Moab site.

No wetlands are known to exist at any vicinity properties, but because desert environments often contain small, isolated wetlands, these properties would be examined for wetlands prior to construction.

3.1.10 Aquatic Ecology

The aquatic resources within the vicinity of the Moab tailings pile are associated with the Colorado River. The river has historically had seasonal variations in flow and temperature that are based on natural flow cycles. Aquatic species in the river have adapted to physical and chemical conditions that fluctuate naturally, both seasonally and daily. These variable conditions include river flow, bottom scouring by sand and silt, temperature, sediment loading, chemical composition, and salinity (NRC 1999).

The Moab site is near river mile 64 on the Colorado River in a transition zone between two geomorphically distinct reaches. River miles on the Colorado River have been designated for use in research programs; the beginning of the designation (mile 0) is at the confluence of the Green River and the Colorado River (Belknap and Belknap 1991; Osmundson et al. 1997). The Colorado River upstream of the site is predominantly sand bedded with a few cobble bars. Downstream of the site, the river is sand bedded with sandbars and stabilized islands. Much of the shoreline near the site has been stabilized by tamarisk, an invasive species, or stabilized with riprap. The tamarisk can form cutbanks that erode to some degree with each large flood. The shoreline at the Matheson Wetlands Preserve opposite the site has been diked and is heavily colonized by tamarisk (NPS 2003).

The State of Utah has classified the river segment adjacent to the Moab site as protected for warm-water species of game fish and other warm-water aquatic life, including necessary aquatic organisms in their food chains. This river segment has also been designated as critical habitat (50 CFR 17.95) for four federal endangered fish species. Detailed information concerning habitat for these species is addressed in Appendix A1, "Biological Assessment."

Macroinvertebrates (i.e., chironomids and oligochaetes) are thought to dominate the benthic community of the main channel of the Colorado River near the Moab site (NRC 1999, USGS 2002). Backwater areas, such as the wetlands formed by periodic inundation of the floodplain just downstream and across the river from the Moab site, may support a much more diverse and more productive benthos. Similarly, rooted macrophytes (i.e., plants), along with algae and zooplankton, flourish in the backwaters that may provide suitable habitat but are almost nonexistent in the main channel (NRC 1999). The backwaters and inundated floodplains often serve as important nurseries and forage suppliers for fish, including the endangered Colorado pikeminnow (Valdez and Wick 1983). Fish species known or believed to be present in this reach are listed in Table 3–9. This list includes four federal endangered species, one state threatened species, and two state species of special concern.

Many components of the upper Colorado River ecosystem have undergone dramatic changes during the last several decades. An additional important force for change has been the sometimes accidental, but often deliberate, introduction of nonnative fish species into the river, including carp, channel catfish, various minnow species, and largemouth bass (NRC 1999). These introductions, in concert with the physical and chemical alterations of the river, may have contributed to the decline of the native fish populations (Trammell and Chart 1999; NRC 1999; Muth et al. 2000).

Table 3–9. Fish That May Occur in the Colorado River Near the Tailings Pile

Common Name	Scientific Name	Status
Roundtail chub	*Gila robusta*	N, ST
Humpback chub	*Gila cypha*	N, FE, SE
Bonytail	*Gila elegans*	N, FE, SE
Colorado pikeminnow	*Ptychocheilus lucius*	N, FE, SE
Longnose dace	*Rhinichthys cataractae*	I
Speckled dace	*Rhinichthys osculus*	N
Fathead minnow	*Pimephales promelas*	I
Carp	*Cyprinus carpio*	I
Red shiner	*Notropis lutrensis*	I
Sand shiner	*Notropis stramineus*	I
Flannelmouth sucker	*Catostomus latipinnis*	N, SP
Bluehead sucker	*Catostomus discobolus*	N, SP
Razorback sucker	*Xyrauchen texanus*	N, FE, SE
Channel catfish	*Ictalurus punctatus*	I
Black bullhead	*Ictalurus melas*	I
Rio Grande killifish	*Fundulus zebrinus*	I
Largemouth bass	*Micropterus salmoides*	I
Green sunfish	*Lepomis cyanellus*	I

Sources: NRC 1999; Trammell and Chart 1999.
N = native to upper Colorado River; ST = State listed threatened species; FE = federally listed endangered species; SE = State listed endangered species; I = introduced species; and SP = State species of special concern

As reflected in the list of species in Table 3–9, as least as many exotic species as native species of fish are now established in the Colorado River.

The roundtail chub, *Gila robusta*, a Utah state-listed threatened species, is a large minnow native to the Colorado River system. It is most often found in pools and eddies near strong currents in the Colorado River and its large tributaries. These chubs eat terrestrial and aquatic insects, mollusks, other invertebrates, fish, and algae. The species spawns over areas with gravel substrate during the spring and summer. Eggs are fertilized in the water, then drop to the bottom where they adhere to the substrate until hatching about 4 to 7 days later (UDWR 2003a).

The flannelmouth sucker, *Catostomus latipinnis*, and the bluehead sucker, *Catostomus discobolus*, are considered Utah state species of concern because of recent population reductions. Both species are benthic fish that primarily eat algae. The flannelmouth sucker spawns in streams over gravelly areas during the spring and early summer and is often found in deep pools of slow-flowing, low-gradient reaches. The bluehead sucker spawns in streams during the spring and summer. Fast-flowing water in high-gradient reaches of mountain rivers has been identified as important habitat for the bluehead sucker (UDWR 2003a).

3.1.10.1 Aquatic Species Listed in the Endangered Species Act

Four endangered fish species—the Colorado pikeminnow (*Ptychocheilus lucius*), razorback sucker (*Xyrauchen texanus)*, humpback chub (*Gila cypha)*, and bonytail (*Gila elegans)*—are endemic to the Colorado River basin. The Colorado River near the Moab site has been designated as critical habitat (50 CFR 17.95) for all four federal endangered fish species. Detailed information concerning habitat and critical life-history phases for these species is presented in Appendix A1, "Biological Assessment."

Colorado Pikeminnow

The Colorado pikeminnow, a large fish-eating fish belonging to the minnow family, was once abundant and widely distributed in the Colorado River basin. Pikeminnow less than 2 inches in total length prey on small aquatic invertebrates in side channels and backwaters; juveniles between 2 and 8 inches total length, still in the backwater nursery habitat, eat invertebrates and other fish; pikeminnow greater than 8 inches total length prey mainly on other fish (Muth and Snyder 1995).

Adult pikeminnow use a variety of habitats after spawning, including eddies, backwaters, and shorelines. In the spring and early summer, the adults use shorelines, floodplain habitats, flooded tributary mouths, and lowlands inundated during spring floods (Tyus 1990; USF&WS 2002a). The pikeminnow spawn on gravel beds in whitewater canyons during the period of declining flows in June, July, or August (Tyus and Haines 1991; Muth et al. 2000; Tyus 1990). During the spawning season, adults have been reported to migrate up to 200 miles upstream or downstream to reach spawning areas (Tyus 1990). After hatching, larvae drift downstream, where they are entrained in backwater nursery habitats (Tyus and Haines 1991). Young Colorado pikeminnow remain near the nursery areas for the first 2 to 4 years of life, then move upstream and establish home ranges (Osmundson et al. 1998). Larval pikeminnow (0 to 1 year) show a preference for secondary channel habitats (Trammell and Chart 1998; Rakowski and Schmidt 1996; Day et al. 1999), and they are primarily found in low-velocity waters, which include backwaters (Tyus and Haines 1991; Trammell and Chart 1998). In the fall, they use backwater habitats that are deeper and more persistent than other habitats (Trammell and Chart 1998; Day et al. 1999). These backwaters are created when a secondary channel is cut off at the upper end but remains connected to the river at the downstream end. These areas are considered crucial for overwinter survival of the larval and juvenile fish (Trammell and Chart 1998).

There are 600 to 900 adults in the upper Colorado River (USF&WS 2002a). The two known spawning areas in this reach of the river are near Grand Junction, Colorado, and in the lower Gunnison River (USF&WS 2002a). Fish and juveniles aged 0 to 1 year are found in the upper Colorado River downstream of Palisade, Colorado, to Lake Powell, Utah (USF&WS 2002a). The Moab site is located on river mile 64 and is within the habitats documented to contain current populations of Colorado pikeminnow. Low numbers of Colorado pikeminnow (between 1 and 28 fish) were consistently collected from 1986 to 1996 between river miles 68 and 49 (USGS 2002). Both adults and subadults were collected in Moab Wash and directly below the tailings pile (USGS 2002). As many as 53 young-of-the-year pikeminnow were captured between river miles 48 and 84 (Osmundson et al. 1997). In a mark-recapture study of adult pikeminnow in this reach, 21 of 51 fish (41 percent) were caught between river miles 57 and 65 (Osmundson et al. 1997). Surveys in 1992 to 1996 by Trammell and Chart (1998) found adult and larval pikeminnow between river miles 55 and 65. In addition, pikeminnow are known to use the main channel for spawning migrations and the backwater area of the Matheson Wetlands Preserve as important nursery habitat (NRC 1999). During periods of inundations, the lower Moab Wash and the riparian woodland near the toe of the pile potentially provide habitat for pikeminnow and razorback suckers (NRC 1999). Other backwaters and eddies occur in this reach during periods of relatively low flow and also serve as nurseries (NRC 1999).

As part of the Interagency Standardized Monitoring Program[1], pikeminnow nursery habitat was sampled each fall (1986–2002) between river miles 53.5 and 63.5. The area surveyed began at or near the Moab site (river mile 64) and continued downstream about 10 miles. The purpose of this sampling was to determine relative abundance and distribution of young-of-the-year Colorado pikeminnow. The sampling protocol required sampling two habitats every 5 miles. Sixty backwater locations were sampled between 1986 and 2002, of which 13 were between river miles 61 and 63.5. Five of the 13 backwater areas sampled contained a total of 83 young-of-the-year pikeminnow, composing 24 percent of the total pikeminnow captured in this reach (river miles 53.5 to 63.5) during the sampling (UDWR 2003b).

From 1992 to 1996, 13 flyovers were conducted to determine backwater habitat in this reach (river miles 53.5 to 63.5).

A field visit with UDWR on December 19, 2001, identified areas that may serve as preferred habitat when backwaters are present. These areas begin at the mouth of Moab Wash and extend approximately 1,200 ft south (Hudson 2001). Within this area, three locations (Figure 3–17) extending about 600 to 800 ft south of the wash were tentatively identified as having the greatest potential for habitat preferred by young-of-the-year fishes. Because natural processes can physically alter the characteristics of river channels, the exact location of preferred habitat can change seasonally or annually. Part of the channel to the west is completely inundated during an average spring runoff in April and May when the river flow is greater than approximately 15,000 cfs. Preferred habitat for young-of-the-year fishes develops in the channel as the river recedes below 15,000 cfs in May and June and the sandbar area becomes exposed. As the river level further declines in the fall, the backwaters in the channel become isolated from the river at approximately 5,000 cfs and evaporate to dryness. Habitat availability and quality depend upon the time of year, changes in river structure, and water level.

USF&WS has defined physical characteristics of preferred habitat to include (1) warmer backwater and slow-moving eddies, (2) a sandy/silty substrate, and (3) water depths of less than 2 ft. However, habitat criteria can be less than optimal if other factors, such as food supply, are attractive. Preference parameters can vary significantly and are not prescriptive.

Razorback Sucker

The endangered razorback sucker is one of the most imperiled fish in the basin. It exists naturally as only a few disjunct populations or scattered individuals (Minckley et al. 1991; Muth et al. 2000). Lack of recruitment sufficient to sustain populations has been mainly attributed to the cumulative effects of habitat loss and modification caused by water and land development and predation on early life stages by nonnative fishes (Hamilton 1998; USF&WS 1998; Muth et al. 2000).

Razorback suckers are known to spawn on gravel bars and may also spawn in backwaters (NRC 1999). In the past, they have been observed spawning in early and mid-summer within 2 miles upstream of the tailings pile (NRC 1999). This type of preferred habitat develops in the channel as the river recedes below 15,000 cfs in May and June and the sandbar area becomes exposed. The razorback sucker may be found almost anywhere in the river, including slow runs

[1] This program is a consortium among the U.S. Fish and Wildlife Service; Bureau of Reclamation; Western Area Power Administration; the states of Utah, Colorado and Wyoming; the water user community; and environmental interests (http://www.desertfishes.org/na/catostom/xyrauche/xtexanus/xtexanus.html).

in the main channel, inundated floodplains and tributaries, eddies and backwaters, sandy bottom riffles, and gravel pits (USF&WS 1998). Young razorback suckers require nursery habitat with warm, shallow water such as tributary mouths, backwaters, or inundated floodplains (Modde 1996; Muth et al. 2000). During periods of inundation, the lower Moab Wash and the riparian woodland near the toe of the pile potentially provide habitat for pikeminnow and razorback suckers (NRC 1999). The Matheson Wetlands Preserve area is also potential nursery habitat for the razorback sucker (NPS 2003). For purposes of this EIS, it is assumed that the razorback sucker may be present in the project area.

A limited number of adults have been found in the upper Colorado River since 1974 (USF&WS 2002b). Many of the adults captured during studies have been found in two abandoned gravel pits in Grand Valley, Colorado, just upstream and downstream of the confluence with the Gunnison River (USF&WS 2002b). No young razorback suckers have been captured anywhere in the upper Colorado River since the mid-1960s (USF&WS 2002b; USGS 2002; NPS 2003).

The diet of all life stages is varied and includes invertebrates, zooplankton, phytoplankton, algae, and detritus (Behnke and Benson 1983; Marsh 1987; Muth et al. 1998, 2000).

Humpback Chub

The humpback chub, a large cyprinid fish, prefers deep canyons with swift water and rapids (USF&WS 2002c; Muth et al. 2000). Adults require eddies and sheltered shoreline habitats maintained by high spring flows. These high spring flows maintain channel and habitat diversity, flush sediments from spawning areas, rejuvenate food production, and form gravel and cobble deposits used during spawning. Young require low-velocity shoreline habitats, including eddies and backwaters, that are more prevalent under base-flow conditions (USF&WS 2002c).

Historical abundance of the humpback chub is unknown, and knowledge of historical distribution is incomplete (Muth et al. 2000; USF&WS 2002c). The species exists primarily in relatively inaccessible canyons of the Colorado River Basin and was rare in early collections (USF&WS 2002c).

Humpback chub move substantially less than other native Colorado River fish. Radiotelemetry and tagging studies consistently show that respective humpback chub populations remain in specific river locations.

Five individuals were collected from a reach about 19 river miles downstream of the Moab site, possibly associated with populations upstream of the Moab site in Westwater Canyon and Black Rocks (NRC 1999; Valdez and Williams 1993).

Six extant wild populations are known in the Upper Colorado Basin: (1) Black Rocks, Colorado River, Colorado; (2) Westwater Canyon, Colorado River, Utah; (3) Yampa Canyon, Yampa River, Colorado; (4) Desolation/Gray Canyons, Green River, Utah; (5) Cataract Canyon, Colorado River, Utah; and (6) Colorado River in Marble and Grand Canyons and the little Colorado River, Arizona (USF&WS 2002c). The nearest downstream population occurs in Cataract Canyon (43 miles downstream of the Moab site) (USF&WS 2002c). UDWR, in cooperation with USF&WS, plans to reintroduce the humpback chub into its historical range upstream of the site in the near future.

Bonytail

The bonytail uses mainstem river channels as well as inundated riparian areas. Currently, no self-sustaining populations of bonytail exist in the wild, and few individuals have been caught throughout the Upper Colorado Basin (USF&WS 2002d). Bonytail have been stocked in this reach since 1996; however, these populations have not thrived, and there has been no recruitment (NPS 2003). Only five individuals, all from Cataract Canyon, were collected during surveys by Valdez and Williams from 1985 to 1988 (NRC 1999). The presence of this rare fish near the Moab site has not been confirmed (NRC 1999).

3.1.10.2 Environmental Tolerances

The aquatic environment in the reach of the Colorado River bordering the Moab site is potentially affected by activities at the site. Ground water flow from the pile has introduced chemical and radioactive contaminants into the surface water (see Section 3.1.7.3). Tolerance of the aquatic biota to the contaminants is dependent on their life-stage, location, and duration of exposure. Appendix A1, "Biological Assessment," provides further information on contaminants and their effects on the aquatic biota.

3.1.11 Terrestrial Ecology

Historically, the entire site has been disturbed from natural events such as floods or from milling operations. At present, the relatively barren terrain of the site limits the potential for terrestrial wildlife habitat, with the exception of the southeasternmost portion of the site, where tamarisk are dominant. Approximately 380 acres of the site do not currently support vegetation. Mature tamarisk, with minimal understory, covers approximately 50 acres of the site east of the tailings pile on the Colorado River floodplain. This area provides some habitat for birds and small mammals. Steep rock mesas dominate the area just west of the site. Low-growing desert shrub communities and low-density piñon-juniper forest are the predominant vegetation types west and north of the site along the transportation routes.

3.1.11.1 Terrestrial Vegetation and Wildlife

The existing vegetation reflects a history of disturbance. Plants observed in April 2003 include spike dropseed (*Sporobolus contractus*), sand dropseed (*Sporobolus cryptandrus*), tamarisk (*Tamarix ramosissima*), black greasewood (*Sarcobatus vermiculatus*), gray rabbitbrush (*Ericameria nauseosa*), Douglas rabbitbrush (*Chrysothamnus viscidiflorus*), big sagebrush (*Artemisia tridentata*), and galleta (*Pleuraphis jamesii*). The presence of tamarisk and low-density black greasewood indicates that ground water occurs within 20 to 50 ft of the surface.

Vegetation across the Colorado River, including the Matheson Wetlands Preserve, provides more attractive habitat and consists of riparian woodland, grassland, and shadscale (saltbush) communities. Woodland, dominated by native tree species such as black willow (*Salix nigra*) and Fremont cottonwood (*Populus fremontii*), is present in the preserve. Other plants include tamarisk, sedges (*Carex* spp.), bulrush (*Scirpus* spp.), and cattail (*Typha* spp.) (NRC 1999). More than 175 species of birds have been observed at the preserve, and a great blue heron (*Ardea herodias*) rookery is present in its lower end (NRC 1999).

Without the current disturbance, the potential natural vegetation (i.e., vegetation that would occur in the absence of disturbance) and habitat of the upland soils at the site, Nakai sandy loam (see Section 3.1.2), would include grasses such as Indian ricegrass (*Achnatherum hymenoides*) and galleta and the desert shrubs fourwing saltbush (*Atriplex canescens*), shadscale (*Atriplex confertifolia*), and winterfat (*Krascheninnikovia lanata*). Because of a relatively high composition and productivity of palatable grasses and shrubs in the potential vegetation (Table 3–10), these plant species would normally be of value as forage for livestock. This relative diversity of the potential vegetation could also provide habitat for a variety of small mammals, including white-tailed prairie dog (*Cynomys leucurus*), desert cottontail (*Sylvilagus audubonii*), and black-tailed jackrabbit (*Lepus californicus*). Fourwing saltbush, shadscale, and galleta may be used to some extent by mule deer (*Odocoileus hemionus*) as forage. Coyote (*Canis latrans*), bobcat (*Lynx rufus*), and badger (*Taxidea taxus*) could frequent this area to prey on the small mammals. Raptors, including golden eagle (*Aquila chrysaetos*), red-tailed hawk (*Buteo jamaicensis*), and rough-legged hawk (*Buteo lagopus*), could also use this area as hunting ground.

Table 3–10. Characteristics of the Potential Vegetation on the Nakai Soil Type

Soil Name	Range Site	Characteristic Potential Vegetation	(percent)	Productivity (pounds/acre)	Rooting Depth (inches)
Nakai	Desert Sandy Loam	Fourwing saltbush (*Atriplex canescens*)	10	350–700	40 to >60 depending on depth to bedrock
		Shadscale (*Atriplex confertifolia*)	10		
		Winterfat *(Krascheninnikovia lanata)*	5		
		Torrey Mormon tea (*Ephedra torreyana*)	5		
		Indian ricegrass (*Achnatherum hymenoides*)	20		
		Galleta (*Pleuraphis jamesii*)	10		
		Sand dropseed (*Sporobolus cryptandrus*)	5		
		Globemallow (*Sphaeralcea* spp.)	10		
		Locoweed (*Astragalus* spp.)	5		

Source: NRCS (2002); SCS (1989).

3.1.11.2 Threatened and Endangered Species

This section describes the terrestrial (plant and wildlife) threatened and endangered species that are, or may be, present in the project area. Threatened and endangered plant and wildlife species are those species listed in 50 CFR 17 as threatened, endangered, or candidate species and are subject to USF&WS Section 7 consultation under the Endangered Species Act (ESA). USF&WS (2003) lists 19 threatened and endangered animal species and 24 threatened and endangered plant species for the state of Utah. In March 2003, DOE requested an updated list of threatened and endangered species from USF&WS that may be present or affected by DOE's proposed alternatives. USF&WS responded in April 2003 with a list for Grand County that included one threatened plant, five threatened and endangered animal species, and two animal species that are candidates for protection under the ESA. These are listed in Table 3–11. UDWR (2003a) has identified the white-tailed prairie dog as being considered for candidate status. The status of each of these species in the vicinity of the Moab site is briefly discussed below. Appendix A1, "Biological Assessment," provides more detailed information concerning these federally listed species that may be in the vicinity of the site or could be affected by activities or contaminants at the site.

<u>Jones' Cycladenia</u>

The federally threatened Jones' cycladenia is known to occur relatively near the Moab site. However, USF&WS has determined that this plant species would likely not be located in the proposed project areas. Jones' cycladenia grows in gypsiferous soils that are derived from the

Summerville, Cutler, and Chinle Formations; they are shallow, fine textured, and intermixed with rock fragments. The species can be found in Eriogonum-ephedra, mixed desert shrub, and scattered piñon-juniper communities at elevations ranging from about 4,000 to 6,800 ft. It is restricted to the canyonlands of the Colorado Plateau in Emery, Garfield, Grand, and Kane Counties, Utah, as well as in immediately adjacent Coconino County, Arizona (UDWR 2003a).

Table 3–11. Federally Listed Terrestrial Threatened and Endangered Species Potentially Occurring at the Moab Site

Common Name	Scientific Name	Habitat Present and Affected	Species Present	Status	Comments
Jones' cycladenia	*Cycladenia humilis* var. *jonesii*	Possible	No	Threatened	None
Southwestern willow flycatcher	*Empidonax traillii extimus*	Possible	Unknown	Endangered	Likely migrate through area
Bald eagle	*Haliaeetus leucocephalus*	Possible	Yes	Threatened	Proposed for delisting
Mexican spotted owl	*Strix occidentalis lucida*	Possible	No	Threatened	None
California condor	*Gymnogyps californianus*	No	No	Endangered	None
Black-footed ferret	*Mustela nigripes*	No	No	Endangered	None
Yellow-billed cuckoo	*Coccyzus americanus*	Possible	Unknown	Candidate	None
Gunnison sage grouse	*Centrocercus minimus*	No	No	Candidate	None

Southwestern Willow Flycatcher

Southwestern willow flycatchers (*Empidonax trailii extimus*) are among the few bird species known to nest in habitat dominated by exotic species such as tamarisk and Russian olive (*Eleagnus angustifolia*), invasive species that are prevalent along much of the Colorado River corridor. However, it appears that higher quality habitat exists where tamarisk is intermixed with other trees and shrubs, along with the presence of natural flood regimes, ample water, and beaver activity (USGS 2001). The southwestern willow flycatcher typically nests in riparian areas with dense thickets of trees and shrubs that are on average 13 to 23 ft in height, with dense foliage from 0 to 13 ft above ground. The percent canopy cover is generally high (50 CFR 17).

The southwestern willow flycatcher has been identified as potentially occurring in the Matheson Wetlands Preserve and also several miles downstream of the Moab site. No nesting activity was observed in these areas, and the species has not been observed on the Moab site proper (NRC 1999). Surveys of potentially suitable habitat were conducted along the Colorado River, approximately 6 river miles south of the site in 2002. Willow flycatchers (subspecies not specified) were present during one survey in May (USGS 2002). The survey report concluded that willow flycatchers in this area were migrating and were not using the area for breeding. These results reflected conclusions of a 3-year study (1999 to 2001). However, the study recommended continued monitoring. No designated critical habitat for this species exists within the site area or along transportation corridors.

It appears that the Moab site is at or beyond the northern extent of the range for the southwestern willow flycatcher. According to UDWR (2003a), the known distribution for the southwestern willow flycatcher in Utah is limited to the southern parts of the state. USF&WS (2002e) identifies southern Utah as the north-central limit of the flycatcher's breeding range. However, a similar subspecies, *E.t. adastus*, occurs at higher elevations in central and northern Utah, and the subspecific identity of these two subspecies in the vicinity of the Moab site remains unresolved (USF&WS 2002e).

Bald Eagle

The bald eagle (*Haliaeetus leucocephalus*) ranges over much of North America, and wintering grounds include many areas in Utah (National Geographic Society 1987). The population throughout the lower 48 states has increased significantly during the last several decades, to the point that USF&WS has submitted a proposal to remove the bald eagle from the list of threatened species (64 FR 36453–36464 [1999]). Bald eagles generally avoid areas with nearby human activity and development. Only four nest sites were known in Utah as of 2000 (UDWR 2003a), and none of these are near the Moab site or any of the other sites considered in this analysis. Nesting habitat for this species is limited in the vicinity of the Moab site and does not exist along the proposed transportation corridors between the Moab site and the proposed borrow locations. The BLM Grand Resource Area Management Plan/Environmental Impact Statement (BLM 1985) identified the threatened bald eagle as potentially occurring in the Moab area. Suitable habitats along the Colorado River in the vicinity of the Moab site are likely wintering areas. The Utah Gap Analysis Program indicates that wintering habitat occurs in the Moab vicinity (UDWR 1999).

Mexican Spotted Owl

The Mexican spotted owl (*Strix occidentalis lucida*) occupies a variety of habitats, including thickly wooded canyons and humid forests (National Geographic Society 1987) to steep rocky canyons, which is the primary habitat used in Utah. These owls do not build their own nests, but utilize nests built by other animals or suitable naturally occurring sites. Preferred nesting sites are in trees with broken tops but are also in trunk cavities or on cliffs. Spotted owls are nonmigratory.

According to UDWR (2003a), the spotted owl's current range in Utah includes most of the southern part of the state, including much of San Juan County. Small patches of known distribution occur in the southernmost part of Grand County and parts of Uinta and Carbon Counties. Many of these areas are also designated by USF&WS as critical habitat (66 FR 85–308553). Within these critical habitat areas are protected and restricted habitat areas. Protected habitat "includes all Mexican spotted owl protected activity centers, all areas in mixed-conifer and pine-oak types with slope greater than 40 percent where timber harvest has not occurred in the past 20 years" (UDWR 2003a). Restricted habitat has a similar, but more general, definition and is not tied to specific protected activity centers (i.e., not tied to known nest sites). BLM has identified potentially suitable habitat (Cresto 2003) within 0.5 mile west of the site on the basis of models developed at Northern Arizona University.

California Condor

California condor (*Gymnogyps californianus*) sightings were historically rare in Utah, noted only twice by pioneers in the 1800s. A nonessential experimental population of California condors was established in northern Arizona in 1996 (61 FR 54043–54060 [1996]). Sightings of the birds that were released in northern Arizona were made nearly statewide in Utah in the late 1990s. The known distribution of the California condor in Utah currently consists of the southern third of the state, including most of San Juan County (UDWR 2003a). Individuals may occasionally pass through the Moab area, but they are not likely to land or use habitat in the vicinity of the Moab site or any of the alternative off-site disposal sites or borrow areas.

Black-Footed Ferret

The range of the black-footed ferret (*Mustela nigripes*) historically covered much of the Great Plains and extended west into eastern Utah. Thought to be extinct until 1981, all individuals now in the wild are thought to be the result of a successful captive breeding and reintroduction program. Unconfirmed sightings of naturally occurring ferrets persist throughout eastern Utah (UDWR 2003a).

Black-footed ferrets depend almost exclusively on prairie dog colonies for food, shelter, and denning. The range of the ferret coincides with that of prairie dogs, and ferrets with young have been documented only in the vicinity of active prairie dog colonies. It has been estimated that about 100 to 150 acres of prairie dog colony are needed to support one ferret (USF&WS 1988). Black-footed ferrets were released in Uinta County, Utah, in late 1999, and UDWR now considers much of the central part of Grand County as Critical Value Habitat. Although there may be a few small prairie dog colonies in the vicinity of the Moab site, the Moab region is not considered high-quality habitat for white-tailed prairie dogs (UDWR 2003a), and it is unlikely that colonies of sufficient size to support ferrets occur near enough to the Moab site to be affected by site operations.

Yellow-Billed Cuckoo

The yellow-billed cuckoo (*Coccyzus americanus*) was listed on October 30, 2001 (66 FR 54807), as a candidate species. Nesting habitat is classified as dense lowland riparian areas characterized by a dense subcanopy or shrub layer (regenerating canopy trees, willows, or other riparian shrubs) within about 300 ft of water. Overstory in these habitats may be either large, gallery-forming trees (33 to 90 ft) or developing trees (10 to 27 ft), usually cottonwoods. Nesting habitat is found at low to mid-elevations (2,500 to 6,000 ft) in Utah. Cuckoos may require large tracts (100 to 200 acres) of contiguous riparian nesting habitat. The yellow-billed cuckoo is thus considered a riparian obligate (UDWR 2003a).

Potentially suitable habitat is located south of the Moab site along the Colorado River and possibly across the river in the Matheson Wetlands Preserve. Surveys conducted from 1999 to 2001 south of the Moab site showed few sightings. Sightings that were documented indicated that this species is using potentially suitable habitat as a migrant and is not using the area as breeding habitat (USGS 2001). However, according to USF&WS, there was a breeding record from the Matheson Wetlands Preserve in 1994 (66 FR 38611–38626 [2001]), located across the Colorado River from the Moab site.

Gunnison Sage Grouse

Although the Gunnison sage grouse (*Centrocercus minimus*) may range into southeastern Grand County, it appears that populations of this species in Utah are essentially restricted to San Juan County (UDWR 2003a). It is unlikely that this species would be present at the Moab site. The Gunnison sage grouse was recognized as a species distinct from the greater sage grouse (*Centrocercus urophasianus*) in 2000 (AOU 2000) and was added to the list of ESA candidate species in 2002 (67 FR 40657–40679 [2002]).

White-Tailed Prairie Dog

A petition to list the white-tailed prairie dog as threatened or endangered under the ESA was submitted by a group of environmental organizations in July 2002 (Center for Native

Ecosystems 2002). USF&WS is currently evaluating this petition and is considering adding this species to the list of candidates for ESA protection. As previously stated, the Moab site is not considered to be quality habitat for this species (UDWR 2003a), and it is unlikely to occur at or near the site in substantial numbers.

3.1.11.3 Other Special Status Species

For this EIS, special status species are those that are protected under federal and state regulations other than the ESA, which include the Migratory Bird Treaty Act (MBTA), Executive Order 13186, and Birds of Conservation Concern (USF&WS 2002f). The State of Utah maintains a list of species that it considers threatened, endangered, or otherwise of concern; other federal agencies such as BLM and the U.S. Forest Service (USFS) maintain lists of species considered to be sensitive. However, only those listed by the USF&WS under the ESA are included in Section 7 consultations or in the Biological Assessment. Although special status species are not covered by the ESA and are, therefore, not subject to Section 7 consultations, USF&WS encourages protection of these species.

Table 3–12 lists sensitive plant species considered by state and federal resource agencies to be of concern that may occur in the site region, including transportation routes and borrow areas. A number of the species listed by the State of Utah, or considered sensitive by BLM, are potentially present in the vicinity of the Moab site.

Table 3–13 includes animal species listed by the State of Utah as endangered, threatened, or otherwise of concern that may be present in the project region. The list includes all species identified by UDWR as potentially occurring in Grand County; in some cases, the known population or suitable habitat is well removed from the Moab site. The species listed as endangered or threatened by UDWR are discussed below.

Peregrine Falcon

Peregrine falcons inhabit mountain ranges, river valleys, and coastlines (USF&WS 1999). They prefer to nest on high cliff ledges (National Geographic Society 1987). Peregrine falcons were one of the first species listed as endangered in 1970 (predating the ESA). After a successful recovery program, they are now much more abundant throughout their range, and the species was ultimately removed from the list of threatened and endangered species in 1999 (64 FR 46541−46558). In Utah, the bird is still rare, but primary breeding habitat exists in small, scattered areas throughout the state. The peregrine falcon is believed to be a year-round resident in the vicinity of the Moab site (BLM 1985).

Ferruginous Hawk

Ferruginous hawks (*Buteo regalis*) are found in grasslands, agricultural lands, sagebrush/ saltbush/greasewood shrub lands, and at the edges of piñon-juniper forests. They tend to avoid high elevations, forests, and narrow canyons. Flat and rolling terrain in grassland or shrub steppe are most often used during breeding season. In winter, they use open, arid areas where rabbits, prairie dogs, and other major prey are found. Nest locations show great flexibility, including trees and shrubs, cliffs, creek banks, utility structures, and abandoned buildings; however, they have a preference for elevated nest sites. Ferruginous hawks are widespread throughout the western United States. In Utah, primary breeding grounds are in northern Grand County and in areas of northern and western Utah.

Table 3–14 lists sensitive bird species, including migratory birds, that may occur in the vicinity of the site, although on-site habitat limits typical nesting and breeding activities. Most of these species are protected under the MBTA, which prohibits take or destruction of birds, nests, or eggs of listed migratory birds.

Table 3–14. Sensitive Bird Species Protected Under the Fish and Wildlife Conservation Act and Migratory Bird Treaty Act That May Occur Near the Moab Site

Species	Potential to Occur in Project Area
Order Gaviiformes—Open-water birds	
Common loon *(Gavia immer)*	Low
Order Ciconiiformes—Long-legged waders	
American bittern *(Botaurus lentiginosus)*	Moderate
White-faced ibis *(Plegadis chihi)*	Moderate
Order Falconiformes—Birds of prey	
Golden eagle *(Aquila chrysaetos)*	High
Northern harrier *(Circus cyaneous)*	Moderate
Prairie falcon *(Falco mexicanus)*	Moderate
Red-tailed hawk (*Buteo jamaicensis*)	High
Turkey vulture (*Cathartes aura)*	High
Order Gruiformes—Marsh and open country birds	
Black rail *(Laterallus jamaicensis)*	Moderate
Yellow rail *(Coturnicops noveboracensis)*	Low
Order Charadriiformes—Shorebirds	
Black tern *(Chlidonias niger)*	Moderate
Long-billed curlew *(Numenius americanus)*	Moderate
Marbled godwit *(Limosa fedoa)*	Moderate
Snowy plover *(Charadrius alexandrinus)*	Moderate
Solitary sandpiper *(Tringa solitaria)*	Moderate
Upland sandpiper *(Bartramia longicauda)*	Low
Wilson's phalarope *(Phalaropus tricolor)*	Moderate
Order Strigiformes—Nocturnal birds of prey	
Barn owl *(Tyto alba)*	Low
Flammulated owl *(Otus flammeolus)*	Low
Short-eared owl *(Asio flammeus)*	Low
Order Apodiformes—Small swallowlike birds	
Black swift *(Cypseloides niger)*	Low
Vaux's swift *(Chaetura vauxi)*	Low
Order Piciformes—Wood-boring birds	
Red-headed woodpecker *(Melanerpes erythrocephalus)*	Low
Williamson's sapsucker *(Sphyrapicus thyroideus)*	Low
Order Passeriformes—Perching birds	
Olive-sided flycatcher *(Contopus borealis)*	Low
Gray flycatcher *(Empidonax wrightii)*	Moderate
Pinyon jay *(Gymnorhinus cyaneocephalus)*	Low
Bendire's thrasher *(Toxostoma bendirei)*	High
Crissal thrasher *(Toxostoma dorsale)*	High
Bewick's wren *(Thryomanes bewickii)*	Moderate
Sedge wren *(Cistothorus platensis)*	Low
Verry *(Catharus fuscenscens)*	Moderate
Sprague's pipit *(Anthus spragueii)*	Low
Loggerhead shrike *(Lanius ludovicianus)*	Moderate

Note: Birds listed in the table are protected under the Fish and Wildlife Conservation Act (Birds of Conservation Concern [2000] [USF&WS 2002f] and the MBTA [50 CFR 10], Executive Order 13186). Species listed as threatened or endangered under the ESA or considered endangered, threatened, or rare by the State of Utah are not included here.

3.1.12 Land Use

Federal, state, city, or county entities administer approximately 90 percent of the land in Grand County. Among federal agencies, BLM administers the greatest percentage of land. Several national parks are in the vicinity of the Moab site. Arches National Park is adjacent to the north border of the site, and Canyonlands National Park is approximately 12 miles (see Figure 2–2) southwest of the site (in San Juan and Wayne Counties). The closest boundary to the Uinta and Ouray Indian Reservation is located approximately 44 air miles north-northwest of the site; however, the closest populated area within the reservation is considerably farther at Duchesne, about 120 air miles north of Moab.

Most of the land in this area is open to recreational uses, and tourism is an important part of the Moab economy. Favorable weather allows off-road access for hikers, bikers, and off-highway vehicles in virtually all seasons. The Colorado River adjacent to the site is a source of extensive recreational use for spring and summer water sports. Because the land directly south of the site adjoins the river and access is not limited, it is often used by campers and hikers throughout the summer months. The entrance to Arches National Park is within 1 mile of the site boundary. It is the northern end of a crescent of national parks and recreation areas that curve southwesterly to the Grand Canyon in Arizona. Most of the visitors to Arches National Park are there for the day only. During 2002, 765,000 visitor days were recorded at the park, of which 41,524 included at least one overnight stay. This park includes exceptional viewpoints and is known for its many spectacular arches.

Grand County has little land suitable for farming. Areas that are suitable for cultivation are limited to Moab Valley and Spanish Valley. Grand County has no prime or unique farmlands. Residential and commercial development has been increasing since 1979, and agricultural use has declined. Grazing occurs throughout the region, including on the plateaus. However, low rainfall and sparse vegetation limit livestock numbers. Except where irrigation is present, federal grazing allotments cover large areas.

Land use in the vicinity of the Moab site is largely commercial, with few residents in the immediate area. The nearest full-time residence is at the northeast corner of the site between Courthouse Wash and the easternmost site boundary. A river tours and gift shop business is located adjacent to the east side of Courthouse Wash. A restaurant, a residence, and two commercial parks for recreational vehicles, motor homes, and trailers are along US-191 approximately 0.75 to 1.5 miles east of the site. Area land use between the Moab and Crescent Junction sites is shown on Figure 3–18.

Land directly south of the site is privately owned and is vacant. The northwest edge of the main residential and commercial area of the city of Moab is across the Colorado River, approximately 1.8 miles southeast of the site.

The land directly across and adjoining the Colorado River to the east is designated as the Matheson Wetlands Preserve. It is jointly owned and managed by UDWR and the Nature Conservancy. The 875-acre preserve includes a trail system, educational kiosks, wildlife viewing platforms, and a water delivery system. Land uses farther downstream along the Colorado River include residences for about 15 families, 100 to 150 acres of forage crops, grazing, and a potash facility (NRC 1999).

The headquarters and staff residences for Arches National Park are located about 1.2 miles northwest of the Moab site. No residences or residential areas, other than those identified above, are known to be located within 2 miles of the site.

3.1.13 Cultural Resources

3.1.13.1 Cultural History of Southeastern Utah

The earliest known humans to inhabit southeastern Utah were believed to have arrived around 10,000 B.C. These paleoindian people were nomadic hunters of large game animals, which at that time included the mammoth, horse, camel, bison, and giant sloth. Stone weapon points from this period have been found in southeastern Utah. These hunters were believed to have migrated out of the area soon after the end of the Pleistocene (Berry 2003).

From 7800 to approximately 500 B.C., Archaic people inhabited southeastern Utah. These were hunter-gatherers who depended more on small game and plants for subsistence. Sometime after 2000 B.C., agriculture was adopted by many of the Archaic people, and a more sedentary, group-oriented lifestyle began. A number of archaeological sites containing evidence of Archaic-age tools, weapons, and structures have been discovered throughout southeastern Utah.

With the advent of horticulture, populations of tribal groups within the southeastern Utah area expanded and diversified. Between A.D. 1 and 1300, several distinct cultural groups inhabited the area, the best known of which were the Anasazi and Fremont. Grand County is thought to have been the northern limit of Anasazi habitation, although some rock art and pottery remains have been found in the Moab and Arches National Park areas. The Fremont group is believed to have inhabited areas primarily north of Moab. Numerous lithic sites, granaries, and storage pits have been found in the area between Arches National Park and the Book Cliffs. The abundant pictographs and petroglyphs discovered throughout southeastern Utah derive from the Anasazi and Fremont people. Both of these groups abandoned the Four Corners region between A.D. 1250 and 1400.

The ancestors of the present-day Ute and Southern Paiute tribes entered southeastern Utah about A.D. 1200. They were mainly hunter-gatherers who hunted and traveled in small bands composed of two to two dozen individuals. By the time Anglo-Americans arrived in southeastern Utah, the San Juan Southern Paiutes and several bands of Utes were well established in the area.

The Ute people were closely tied to the land, not so much through agriculture but through hunting and gathering; thus, their survival depended heavily upon having complete access to the land (Cuch 2000).

In the late 1800s and early 1900s, their free-roaming lifestyle ended when the Utes were removed from their ancestral lands and forced onto reservations. Today, the Ute bands that once roamed the lands of southeastern Utah are concentrated in reservations in a number of areas: the White Mesa Ute community 9 miles south of Blanding, Utah; the Ute Mountain Utes in Towaoc, Colorado; the Southern Utes in Ignacio, Colorado; and the Northern Utes in White Rocks, Fort Duchesne, and Randlett, Utah.

The Navajos migrated into the Four Corners region sometime between A.D. 900 and 1400. In San Juan County, the earliest known Navajo site, discovered in White Canyon (adjacent to the

Colorado River and west of Blanding), is estimated to be 380 years old. Several Spanish maps dating from the 1660s pictured Navajo territory as far north as the present-day town of Green River, Utah (Cuch 2000). However, the primary homeland of the early Navajos was in a large area known as Dinétah, located southeast of present-day Farmington, New Mexico.

In 1868, a treaty was signed between the Navajos and President Andrew Johnson that allowed the Navajos to return to their homeland. Today, 110 chapters of the Navajo Nation are located in northern Arizona, northwestern New Mexico, and southeastern Utah. The Aneth and Red Mesa Chapters in southeastern Utah are approximately 30 and 45 miles, respectively, southeast of the White Mesa Mill site.

Spanish explorers and traders traveled through southeastern Utah from the late 1600s to about 1848, when Mexico ceded to the United States the tract of land south of the forty-second parallel, including the state of Utah. The best known of the explorers were Juan María Antonio de Rivera, who traveled the area in 1765, and Francisco Atansio Domínguez and Francisco Silvestre Vélez de Escalante, who traveled the area in 1776. During this period, the Old Spanish Trail was developed as a major trade route between California and Santa Fe, New Mexico Highway. I-70 to Denver and the Union Pacific Railroad line follow the northern branch of this route, and US-191 from Crescent Junction to Blanding follows the historic main branch of the trail (Berry 2003).

The first Anglo-Americans to settle the southeastern Utah area were Mormon missionaries. They came in 1855 to convert the Utes to Mormonism and teach them farming. During their brief stay at the Elk Mountain Mission, which they constructed north of present-day Moab, they raised cattle and grew crops. Their efforts were soon thwarted by conflicts with the Utes, and they departed the area "in haste" about 4 months after their arrival. Mormon farmers and ranchers did not permanently settle southeastern Utah until 1877, when the United States signed a peace treaty with the Ute Tribe and established reservations in eastern Utah and southwestern Colorado (Firmage 1996).

Prospectors settled in the Moab area between the 1880s and 1920s to mine gold, copper, uranium, and radium. Moab, Grand County, and southeastern Utah were forever changed by a uraninite discovery on July 6, 1952, by Texas prospector Charles A. Steen. His strike was the richest single lode of uranium ore discovered anywhere to that date and led to Moab becoming the "Uranium Capital of the World." Steen built his own $8 million processing mill on the north side of the Colorado River 3 miles north of Moab in 1956. In 1962, the Atlas Corporation purchased Steen's mill for $25 million and operated it until it closed in April 1984. This mill operation generated the tailings pile that is the subject of this document (NRC 1999).

3.1.13.2 Cultural Resource Inventories of Potentially Affected Areas

DOE contracted two professional archaeological consultants to conduct Class I cultural resource inventories of areas that could be affected by the proposed alternatives (Berry 2003; Davis et al. 2003). Class I inventories are inventories of existing cultural resource data. Archaeologists study published and unpublished documents, records, files, and other sources to determine if previous cultural resource investigations have been conducted within an area. If cultural resources have been identified, the federal agency conducting the action, in consultation with the State Historic Preservation Officer and affected Native American tribes, determine whether the cultural resources are included or are eligible for inclusion in the National Register of Historic Places. DOE is required by the National Historic Preservation Act to consider the effects of its actions on any "district, site, building, structure, or object" that is included or eligible for inclusion in the National Register of Historic Places. If DOE's action would have an adverse effect on an eligible cultural resource, DOE would be required to implement a process called the Section 106 consultation process. This process would require DOE to consult with the State Historic Preservation Officer and others in an effort to find ways to make the action less harmful. Others who would be consulted might include Native American tribes, BLM, NPS, UDOT, Bureau of Indian Affairs, and other federal and state agencies, organizations, and private individuals.

The National Historic Preservation Act also requires DOE to inventory surface and subsurface cultural resource sites in areas before they are disturbed. These on-the-ground "Class III" surveys would be conducted by professional archaeologists before DOE implemented any of the proposed alternatives. A Class III survey is "a continuous, intensive survey of an entire target area, aimed at locating and recording all archaeological properties that have surface indications, by walking close-interval parallel transects until the area has been thoroughly examined" (BLM 2003a).

Some culturally significant properties or places may be eligible for inclusion in the National Register of Historic Places but may not be readily identifiable by archaeologists during a Class I inventory or Class III survey. These "traditional cultural properties" may be associated with the cultural practices or beliefs of a community and may be significant to the community's history or may be important in maintaining the community's cultural identity. The National Historic Preservation Act requires that these properties or places be considered by federal agencies in the same manner as other eligible cultural resources through the Section 106 consultation process. To identify traditional cultural properties that may be affected by its proposed actions, DOE contracted a cultural anthropologist to assist in communicating with tribal members who may have knowledge of such properties. Because Class III cultural resource surveys have not yet been completed in many portions of the project area, all potential traditional cultural properties cannot yet be identified. Information contained in this EIS concerning traditional cultural properties is preliminary and not complete. Once a preferred alternative is selected, site-specific studies and additional interviews would be conducted in conjunction with the Class III surveys to identify all potential traditional cultural properties.

3.1.13.3 Section 106 Consultation Process

In April 2003, DOE initiated the Section 106 consultation process by notifying potentially interested stakeholders that DOE was preparing this EIS. DOE contacted federally recognized Native American tribes that resided in or had cultural ties to the project area to inform them of DOE's proposed alternatives and to solicit their concerns or comments. A total of 38 representatives from 14 Native American tribes and the Navajo Utah Commission were contacted by mail and telephone. To date, the Ute Mountain Ute Tribe (including White Mesa Ute Tribe), Southern Ute Tribe, Uintah-Ouray Ute Tribe, Navajo Nation (including Aneth Chapter, Red Mesa Chapter, and Oljato Chapter), Navajo Utah Commission, and Hopi Tribe have expressed interest in or concerns with DOE's proposed alternatives.

DOE also contacted potentially affected federal agencies, including BLM, NPS, Bureau of Indian Affairs, and UDOT about the proposed alternatives. BLM and NPS are cooperating agencies for the EIS.

3.1.13.4 Moab Site Inventory Results

DOE contracted a Class III cultural resource survey of the Moab site in January and March 2004 (Christensen 2004; Christensen and Lindsay 2004 [in progress]). As a result of that survey, DOE determined that five cultural sites eligible for inclusion in the National Register of Historic Places are present on DOE property. The eligible sites include (1) a prehistoric site, (2) a section of the historic US-160 that parallels and pre-dates the present-day US-191, (3) a sign identifying the historic livestock driveway from Moab to Crescent Junction, (4) a collapsed farmstead dating from the Depression era, and (5) the remaining structures associated with the uranium mill. The primary contributing features associated with the historic millsite include the Uranium Reduction Company general office/warehouse/machine shop, Colorado River pump station and pipeline, ore loadout structure on the railroad spur, and scale house. Although the millsite features are less than 50 years old, DOE determined that they are eligible for nomination to the National Register of Historic Places, primarily because of their association with the "greatest mining boom in American history" (Christensen 2004), a boom that facilitated the Unites States' dominance as a nuclear superpower. The features also are "representative of the uranium milling industry that brought many jobs to Grand County, contributing to the current community structure of Moab to a degree far greater than any other single mechanism in regional history" (Christensen 2004).

One recorded traditional cultural property associated with the Ute Tribe is present near the Moab site (Berry 2003).

3.1.14 Noise and Vibration

Noise is technically defined as sound waves that are unwanted and perceived as a nuisance by humans. Sound waves are characterized by frequency and measured in hertz (Hz); sound pressure is expressed as decibels (dB). Humans have a perceptible hearing range of 31 to 20,000 Hz. The threshold of audibility ranges from about 60 dB at a frequency of 31 Hz to less than about 1 dB between 900 and 8,000 Hz. For regulatory purposes, noise levels for perceptible frequencies are weighted to provide an A-weighted sound level [dBA] that correlates highly with individual community response to noise. Sound pressure levels outside the range of human hearing are not considered noise in a regulatory sense, even though wildlife may be able to hear at those frequencies. A better understanding of noise impacts is facilitated by associating noise levels with common activities or sources (Figure 3–19).

Noise levels are often reported as the equivalent sound level (L_{eq}). The L_{eq} is expressed in dBA over a specified period of time, usually 1 or 24 hours. The L_{eq} is the equivalent steady sound level that, if continuous during

Noise Measurement

What are *sound* and *noise*?

When an object vibrates it possesses energy, some of which transfers to the air, causing the air molecules to vibrate. The disturbance in the air travels to the eardrum, causing it to vibrate at the same frequency. The ear and brain translate the vibration of the eardrum to what we call *sound*. *Noise* is simply unwanted sound.

How is sound measured?

The human ear responds to sound pressures over an extremely wide range of values. The range of sounds people normally experience extends from low to high pressures by a factor of 1 million. Accordingly, scientists have devised a special scale to measure sound. The term decibel (abbreviated dB), borrowed from electrical engineering, is the unit commonly used.

Another common sound measurement is the A-weighted sound level, denoted as dBA. The A-weighting accounts for the fact that the human ear responds more effectively to some frequencies than others. Higher frequencies receive less weighting than lower ones. Most of the sound levels provided in this report are A-weighted; however, some are in decibels because of lack of information on the frequency spectrum of the sound. Figure 3–19 shows common references to sound on the A-weighted sound-level scale.

SOUND SOURCE	SOUND LEVEL (dBA)	RESPONSE
Carrier deck jet operation	140	
Civil defense siren (at 100 ft)	130	Painfully loud
Jet takeoff (at 200 ft)	120	Threshold of feeling and pain
Riveting machine (at 1 ft)	110	
Ambulance siren (at 100 ft)	100	Very loud
Heavy truck (at 50 ft)	90	
Freight train cars (at 50 ft)	80	
Vacuum cleaner (at 10 ft)	70	Moderately loud
Air conditioning unit (at 20 ft)	60	
Speech in normal voice (at 15 ft)	50	
Residence, no TV or radio	40	Quiet
Soft whisper (at 5 ft)	30	
Recording studio	20	
	10	
	0	Threshold of hearing

Figure 3–19. Comparison of A-Weighted Sound Pressure Levels Associated With Different Sources of Noise

a specified time period, would contain the same total energy as the actual time-varying sound over the monitored or modeled time period. Another expression of noise levels is the day-night sound level (L_{dn}). This is the average of the day and nighttime A-weighted sound level with a built-in penalty of 10 dB at night. The L_{dn} is particularly useful for evaluating community-level noise effects.

The Moab site is located in a quiet, open desert environment where natural phenomena such as wind, rain, and wildlife account for most natural background noise. At times, insect activity and birds may account for significant portions of environmental noise. The Arches National Park is a potential sensitive site located close to the Moab site. The park maintains two housing complexes near the park entrance. The housing complex that is closer to US-191 provides temporary housing for seasonal employees, students, and official visitors but does not have any permanent residents. The permanent housing complex is located farther from US-191 and consists of three permanent residences for park employees and families. Sources of man-made background noise near the Moab site may include automobile traffic on US-191, trains on the Union Pacific Railroad, aircraft flying overhead, and outdoor recreational activities in adjacent areas.

The city of Moab is located about 3 miles southeast of the Moab site and is outside the influence of noise originating at the site. Expected noise levels in and around the city of Moab likely range from 45 to 55 dBA, with levels approaching 65 dBA around busy roads. The city of Moab has a noise ordinance specifying that noise levels not exceed 65 dBA (Moab City Ordinance 17.74.080, "Noise Levels"). This applies to residential zones from 10:00 p.m. to 7:00 a.m. Monday through Saturday and not before 9:00 a.m. on Sunday. For commercial zones, the standard applies to the time interval between 10:00 p.m. and 6:00 a.m. the following day. The acoustic environment in open desert in Utah is typical of other desert environments where average L_{dn} values range from 22 dB on calm days to 38 dB on windy days (Brattstrom and Bondello 1983).

Ground vibration is generally not perceived as a characteristic of the environment because background ground vibration is not perceptible to humans. Ground vibration is expressed as the average vibration root mean square (rms) velocity in decibels (expressed as dBV) with a reference to 10^{-6} inch per second. The highest mean value of rms velocity over a given event is called the maximum rms velocity. It is a more suitable expression of ground vibration energy for addressing human annoyance because of the response time for humans to respond to ground vibration stimuli. The human threshold for the perception of ground vibration is 62 to 65 dBV. A large truck or bus can produce ground vibration levels of about 62 dBV. About 70 dBV will result in notable human response.

Natural sources of ground vibration include wave action, strong winds striking natural or man-made structures, and, infrequently, seismic activity. Human activities that can create perceptible levels of ground vibration (such as blasting, pile driving, operation of heavy earth-moving equipment, or rail traffic) are important when sensitive sites, structures, or activities may be affected. The most significant background component of ground vibration in the Moab area is railroad traffic.

No background noise or ground vibration data are available for the Moab site. A single residence is located to the northeast of the site; otherwise, there are no residences located close to the site.

3.1.15 Visual Resources

Visual resources are the visible physical features of a landscape that impart scenic value. Southeastern Utah is known worldwide for its unique scenic qualities and unusual landscape features. It is a land of deep canyons, rock arches, towering rock formations, badlands, and expansive panoramas. Many of the more spectacular features are preserved in national and state parks or monuments, three of which—Arches and Canyonlands National Parks and Deadhorse Point State Park—are located near Moab, and one of which—Natural Bridges National Monument—is located west of Blanding.

BLM has developed a Visual Resource Management system that helps federal agencies classify and manage landscapes and their associated scenic values. The system allows landscapes to be ranked and placed into one of four classes. Each class has a management objective that is related to the value placed on the scenic characteristics of the landscape (BLM 2003b).

Class I Objective: Preserve the existing character of the landscape. The level of change to the characteristic landscape should be very low and must not attract attention.

Class II Objective: Retain the existing character of the landscape. The level of change to the characteristic landscape should be low. Management activities may be seen but should not attract the attention of the casual observer. Changes must repeat the basic elements of form, line, color, and texture of the predominant natural features of the characteristic landscape.

Class III Objective: Partially retain the existing character of the landscape. The level of change to the characteristic landscape should be moderate. Management activities may attract attention but should not dominate the view of the casual observer. Changes should repeat the basic elements of the predominant natural features of the characteristic landscape.

Class IV Objective: Provide for management activities that require major modifications of the existing character of the landscape. The level of change to the characteristic landscape can be high. These management activities may dominate the view and be the major focus of viewer attention. However, every attempt should be made to minimize the impact of these activities through careful location, minimal disturbance, and repetition of basic elements.

BLM classifies BLM-managed lands surrounding the Moab site as Class II, primarily because of the nearness of the Colorado River, Arches National Park, and stunning landform features in the area (BLM 2003b).

The Moab site is on the floodplain of the Colorado River and is immediately adjacent to US-191 and Potash Road SR-279. Depending on the viewing location, the backdrop to the site may be the steep, red sandstone cliffs that define the western edge of Moab valley; The Portal, where the Colorado River re-enters its steep, narrow canyon; or the towering and often snow-covered La Sal Mountains. In any direction, the contrasts in the green-patchwork valley floor and vertical red cliffs impart a spectacular quality to the views.

The Moab site tailings pile can be viewed by northbound and southbound travelers on US-191 and Potash Road and by tourists from two unmarked scenic turnouts on the Arches National Park road. The tailings pile is a relatively large, flat, geometrically shaped landform that has smooth steep side slopes on the south and east sides and terraced, step-like side slopes on the north and west sides. The predominant horizontal lines created by the pile provide a moderate contrast to the adjacent vertical sandstone cliffs; however, the red color of the soils currently covering the tailings blends with the reds of the surrounding cliffs, allowing the pile to go unnoticed by many first-time visitors to the area. Because of its size, the tailings pile moderately to strongly dominates the view from most of the viewing locations. It can be seen from one residence located directly northeast of the site and a residence at The Portal RV and Park across the river from the site. Figure 3–20 shows the current view of the tailings pile from southbound US-191.

Figure 3–20. View of the Moab Site Tailings Pile from Southbound US-191
[Before UDOT widened US-191]

3.1.16 Infrastructure

3.1.16.1 Waste Management

Nonradioactive solid waste at the Moab site is disposed of by a commercial contractor in the Grand County landfill, which has a remaining projected lifespan of 64 years at a disposal rate of 30,000 to 35,000 yd^3 per year.

Currently, two portable toilets are on the site for managing nonradioactive sanitary waste. Each portable toilet can support up to 25 workers. The sanitary waste is emptied from the portable toilet one or two times per week, depending on the size of the on-site workforce and is disposed of by a commercial contractor in the Moab sewage treatment plant, which has a capacity of 1.5 million gallons per day. The treatment plant currently treats an average of 800,000 to 900,000 gallons per day; it restricts discharge of concentrated sewage from portable toilets to 9,000 gallons per day and limits receipts to 3 days per week.

3.1.16.2 Electrical Power Supplies

A three-phase overhead power line runs along the north boundary of the property, and an electrical substation on the property feeds power to the site. The electrical utility servicing the site is Utah Power, a subsidiary of PacifiCorp.

3.1.16.3 Water

The Moab site has its own pump station that can pump nonpotable water from the Colorado River. DOE currently has a water right for consumptive use of Colorado River water at the Moab site of 3.3 cfs (approximately 2,366 acre-feet per year). This right includes an additional 3.03 cfs (about 2,194 acre-feet per year) for nonconsumptive use. Potable water is available in the city of Moab. The city's potable water supply system is provided by the Glen Canyon aquifer (see Section 3.1.6.4) and can produce 3 million to 5 million gallons per day.

3.1.17 Transportation

3.1.17.1 Vehicular Traffic

US-191 provides highway access to the Moab site. It is generally two lanes wide but does have occasional passing lanes. Originating at the Arizona-Utah border and terminating at the Crescent Junction and I-70 intersection, US-191 provides north-south travel access in eastern Utah and also carries significant truck traffic. As much as 30 percent of the total vehicle volume consists of trucks.

Table 3–15 presents a summary of annual average daily traffic (AADT) counts, degree of congestion, percentage of truck traffic, number of accidents, and accident rates for US-191 between the White Mesa Mill site and Crescent Junction where it intersects with I-70. AADT volume is based on vehicle counts from continuously operating automatic traffic counters that do not discern direction of travel. The reported AADT is a combination of vehicles traveling in both directions for a specific route segment. Congestion is a reflection of the actual number of vehicles on a highway segment in relation to how many the road can safely handle. Various other factors, such as the geometry of the roadway and number of lanes, are also considered in determining whether a road is congested. Truck traffic is defined as single-unit delivery trucks or larger sized vehicles. Truck traffic is shown as a percent of the AADT. Accident rates are determined by comparing actual recorded crashes to expected accident rates for a specific road segment and per 1 million miles of vehicle travel. Expected accident rates are a 5-year average of accidents that occur on similar highway segments and include all types of vehicles. The rates provided in Table 3–15 are based on the 1997–2001 time period (Ames 2003).

As shown in Table 3–15, central Moab is considered congested and had a high accident rate of 3.5 accidents per 1 million miles of vehicular travel in 2001. Based on accident averages, it was expected to have an accident rate of 1.77. US-191 increases to four lanes in the downtown area to accommodate the increase in traffic. Within 1,400 ft of the north city limits, US-191 reduces to two lanes, congestion is no longer a problem, and the accident rate reduces to low, which is characteristic of most sections of US-191 (Ames 2003). It is assumed that the large increase in traffic volume in the downtown area reflects downtown business activity and cross traffic that stays within the city. No state or federal routes converge with US-191 in Moab.

The city of Moab is concerned about traffic congestion within the central area, which continues to get progressively worse as the city grows and attracts increasing tourism and tourism-related commerce and recreation. The city has considered a bypass to relieve traffic congestion; however, it has not yet begun a feasibility study (Vaughn 2003).

Table 3–16. Average Monthly Vehicle Traffic Near the North Boundary of Moab

Month	2000		2001		2002	
	Traffic Count	Percent Change From Previous Month	Traffic Count	Percent Change From Previous Month	Traffic Count	Percent Change From Previous Month
January	2,902		2,847	–12	2,938	–9
February	3,324	15	3,251	14	3,638	24
March	5,257	58	5,312	63	6,443	77
April	7,212	37	7,235	36	6,915	7
May	7,646	6	7,627	5	7,913	14
June	7,722	1	6,897	–10	7,136	–10
July	7,601	–2	6,519	–5	6,715	–6
August	6,052	–20	6,542	0.4	6,400	–5
September	6,703	11	6,433	–2	6,590	3
October	6,068	–9	5,866	–9	6,357	–4
November	3,554	–41	4,340	–26	4,146	–35
December	3,252	–8	3,216	–26	3,582	–14
Year Totals	**67,293**		**66,085**		**68,773**	

Reference: UDOT 2002a.

Numerous county roads in the area (see Figure 3–21) are used for recreational travel by off-highway vehicles, motorcycles, or mountain bikes to backcountry areas. Some of the roads are former highway routes that pre-date I-70 construction and some are the result of seismic exploration activities.

CR-138, 1 mile south of the Canyonlands Field Airport, is locally known as Blue Hills Road. This is a dirt surface, two-lane road that carries heavy off-highway vehicle traffic to backcountry areas. The road surface is wider than the typical two-lane road. During the peak summer use season, 100 vehicles per day may travel the road (Vaughn 2003). BLM recorded 53,000 vehicle counts on CR-138 during a 12-month period in 2002. Although there are many connecting road choices, it is believed that the majority of the vehicles also return to US-191 by using CR-138 (Von Koch 2003).

CR-236 provides access to the Grand County landfill, locally known as the Klondike landfill, and to a radio tower. The landfill is about 1 mile west of US-191 and is operated by the Grand County Solid Waste District. The amount of daily traffic accessing the landfill on this road is unknown. CR-236 continues as a dirt track past the landfill.

Another former highway alignment out of use since about 1911 is CR-144, also known as the Thompson Cut-Off Road. This road has a gravel surface and is locally used to access I-70 at Thompson Springs.

CR-175 is north of I-70 at Crescent Junction. This road also predates I-70 and still carries local or frontage road traffic from Crescent Junction to Thompson Springs or farther to a point near Cisco. It is a two-lane road from Crescent Junction to the bridge over Thompson Wash, where it narrows to one lane because of the condition of the bridge. It continues as a two-lane road east of Thompson Springs. Although there may be occasional local use of this frontage road, most of the asphalt pavement is deteriorating and would need resurfacing for any sustained increase in use.

The stretch of US-191 area between the Canyonlands Field Airport (Blue Hills Road) and CR-334 to the north is locally considered a potentially dangerous section of the highway. The combination of terrain, slower moving vehicles, and the two-lane limitation can create dangerous passing situations (Vaughn 2003). In addition, according to UDOT highway statistics, a 2-mile stretch of US-191 south of Blue Hills Road sustains more accidents than expected (Ames 2003).

To relieve congestion associated with traffic in the Arches National Park entrance area, a new entrance road has been constructed within the park that will connect with US-191 approximately three-quarters of a mile south of the existing entrance to the park.

In 2004, UDOT upgraded US-191 to four lanes from the area just north of SR-128 to the area just north of SR-313; adding two turn lanes at the entrance to Arches National Park, at Gemini Bridges, and at SR-313; adding a 2-mile-long bicycle lane on the northeast side of US-191; and adding center divides along some stretches of US-191.

3.1.17.2 Rail Transport

The Union Pacific Railroad parallels I-70 and offers predominantly freight rail service. On a daily basis, there is usually one Burlington Northern train carrying 75 to 100 cars of mixed manifest; two to three freight trains of 105 to 134 empty coal cars; one to two loaded coal trains of 105 cars; and an east-bound passenger train and a west-bound passenger train. The California Zephyr passenger train stops in Green River, Utah, and Grand Junction, Colorado (Legg 2003).

The Cane Creek Branch of the Union Pacific Railroad parallels US-191 and provides weekly freight service to the Moab Potash and Salt Mine. It carries potash and salt to Crescent Junction and continues on the Union Pacific Railroad to Grand Junction for distribution to points east and west. This train consists of between 40 and 50 cars. It does not stop between the Moab Potash and Salt Mine and Crescent Junction but does cross several county roads with unguarded and unmarked rail crossings. As shown on Figure 3–21, just north of Blue Hills Road (CR-138), the railroad crosses under US-191 from the east to the west side, where it continues south toward the Moab Potash and Salt Mine. At the Blue Hills Road crossing, there is a stop sign but no rail guard arms or signal. After traversing a tunnel, the railroad emerges several miles from the Moab Potash and Salt Mine and continues on the north side of SR-279. The Moab Potash and Salt Mine is located 16 miles from the intersection of US-191 and SR-279.

There was one recorded fatality on the Cane Creek Branch during the period of 1974 or 1975 to 2003. Injuries of all kinds for all travel on the Union Pacific Railroad are reported as averaging 2.9 per 100,000 man-hours of work. Derailments are reported per ton-mile and were estimated at possibly 0.009 percent (Legg 2003).

3.1.18 Socioeconomics

This section describes the socioeconomic environment of Grand and San Juan counties, Utah, in terms of their demographic, economic, and natural resource features.

3.1.18.1 Population, Workforce, and Job Base

Grand County covers 3,689 square miles and had a 2000 census population of 8,485. Its population has grown 28.2 percent since 1990. Prior to 1990, the population declined by 19.7 percent relative to 1980 levels, coinciding with the closure of the Atlas mill in 1984. The recent trends in population growth mark a turnaround; tourism-recreation now forms the basis of economic activity and growth in the regional economy. This fundamental change reflects that the minerals industry (uranium, potash, oil, and gas), which in 1980 directly and indirectly generated 62 percent of all income of Grand County residents, now contributes only 2 percent to the overall labor income. Table 3–17 provides population information for Grand and San Juan Counties.

Table 3–17. Population and Labor Force Information for Grand and San Juan Counties, Utah

Demographic Features	Grand County	San Juan County
2000 population	8,485	14,413
1990–2000 percent change	28.2	14.2
1980–1990 percent change	–19.7	3.0
2000 population per square mile	2.3	1.8
2000 civilian labor force	5,164	4,593
1999–2000 percent change	–4.5	–6.0
2000 unemployment rate	6.5	9.2
Government employment		
Federal	245	285
State-local	545	1,313
Total	**790**	**1,598**

From 2000 Census
Source: U.S. Census Bureau, County and City Data Book: 2000

Population effects from tourism and recreation are most notable in Moab, the Grand County seat. Moab is the largest town in southeastern Utah, and in the 2000 census had a permanent population of 4,779. At the time of the 2000 census, more than half of Grand County's population resided in Moab. By comparison, San Juan County covers 8,103 square miles and had a reported population of 14,412 during the same census period. This county also experienced accelerated population growth during the last 2 decades. It grew 3 percent between 1980 and 1990 and 14.2 percent between 1990 and 2000. According to the 2000 census, the population density in San Juan County is lower than in Grand County, averaging 1.8 individuals per square mile, compared to Grand County's density of 2.3 individuals per square mile. The population density of both counties is well below the statewide average of 27.2 persons per square mile.

Table 3–17 also provides labor force information for Grand and San Juan Counties. The civilian component of the labor force is similar in size for the two counties, numbering 5,164 in Grand County and 4,593 in San Juan County. This labor force is primarily employed by a service economy founded on tourism-recreation, especially in Grand County. The combination of federal, state, and local government employment is nearly twice as high in San Juan County relative to Grand County, mostly because of the state and local components. Despite the larger number of government jobs in San Juan County, its local unemployment rate was 9.2 percent, compared to 6.5 percent in Grand County. Both counties had significantly higher unemployment rates during the first half of 2000 compared to the state average of 3.7 percent. These indicators of human resource availability vary because of the seasonal nature of employment opportunities and job turnover rates in the tourism-recreation job base. For example, seasonal unemployment in Grand County has ranged from 6.2 percent to 7.3 percent (GPU 2003).

Meanwhile, over the longer term (since 1995), tourism-recreation employment has grown by some 20 percent, now accounting for at least 45 percent of Grand County's total employment (GPU 2003). An estimated 1,878 jobs are now tourism-related (GPU 2003). By comparison, mining has decreased from a 16-percent share of total area employment in 1995 to a 2-percent share in 2000, and government employment has increased from 10 to 19 percent (GPU 2003). Federal land management agencies are among the major employers in the regional economy. At the center of this activity is the city of Moab, which acts as a gateway to Arches and Canyonlands National Parks, as well as Dead Horse Point State Park and the famous Slickrock Bike Trail. In the year 2000, Arches National Park attracted some 790,000 visitors, and Canyonlands National Park received 400,000 visitors.

3.1.18.2 Housing and Income Characteristics

Census data for 2000 show significant increases in both the number of housing units and the number of households in the study region. In Grand County, the number of housing units increased by more than 35 percent compared to 1990 levels, and the number of households increased by 38 percent relative to 1990 levels. Although the growth rates for San Juan County tended to be half as large as those of Grand County, the residents of San Juan County had a larger percentage of owner-occupied dwellings (79.3 percent compared to 71 percent). Table 3–18 provides information on housing and income characteristics in Grand and San Juan counties.

Table 3–18. Housing and Income Information for Grand and San Juan Counties, Utah

Housing and Income	Grand County	San Juan County
2000 housing units	4,062	5,449
1990–2000 percent change	35.8	17.2
Percent owner occupied	71.0	79.3
Number of households	3,434	4,089
1990–2000 percent change	38.0	21.2
1997 median household income (1997 dollars)	$28,881	$26,723
1989–1997 percent change	33.1	54.6
1998 per capita income	$19,505	$12,685
Percent of national average	71.7	46.6
Percent of Utah average	87.7 (71.7/81.8)	56.9 (46.6/81.8)

Source: U.S. Census Bureau, County and City Data Book: 2000. Percentage of Utah average is calculated by dividing the county per capita income as a percentage of national average (71.7 percent and 46.6 percent, respectively) by the state per capita income as percentage of national average (81.8 percent).

Temporary housing and accommodations in Moab are available for the large influx of tourist and recreational visitors in various forms, including motels and hotels (1,583 rooms); bed and breakfasts, apartment units, condominiums, and guest houses (278 rooms); and numerous campsites (GPU 2003). Additional temporary housing and accommodations are available in the towns of Monticello and Green River. For example, Monticello (55 miles south of Moab) has more than 200 motel and hotel rooms, 2 bed and breakfasts, and 5 campsite-RV parks. Temporary housing accommodations in Green River include 650 hotel and motel rooms, 1 bed and breakfast, and 3 camp parks.

The vacancy rates for temporary housing in Moab tend to follow the pattern of the seasonal tourist economy. The availability of apartment rental units, as well as mobile homes and trailers, is greatest between November and mid-February. By early spring, most rental units are occupied by seasonal employees staffing motels, restaurants, shops, and other tourist service businesses (e.g., bike shops, raft tour companies). Outside of Moab, temporary housing is also limited to a few motels, trailers, and campgrounds in towns such as Green River (52 miles northwest of Moab), Monticello (54 miles south of Moab), and Blanding (78 miles south of Moab).

Table 3–18 also reports median household incomes (1997) and per capita incomes (1998) for the two counties. These statistics suggest that the typical resident of Grand County had a slightly larger median household income and a relatively larger per capita income than the typical resident in San Juan County. The similarity of values for median household incomes is attributable to relatively faster income growth in San Juan County during 1989 to 1997 (54.6 percent compared to Grand County's 33.1 percent). Per capita income in San Juan County is less than that of Grand County ($12,685 compared to $19,505) and makes up only 56.9 percent of the average per capita income in Utah and only 46.6 percent of the average per capita income in the United States. By comparison, Grand County's per capita income is closer to the state and national averages (87.7 percent and 71.7 percent, respectively).

3.1.18.3 Commercial Business and Farm-Based Enterprise

In 1998, there were an estimated 360 private nonfarm businesses in Grand County, many supporting the expanding tourism-recreation sector. The number of private businesses in Grand County grew by 67.4 percent between 1990 and 1998, reflecting a period of relative prosperity in the local and regional economy. In 2000, tourists spent an estimated $99.2 million in Grand County, making it the seventh highest county for tourist dollars spent in Utah (GPU 2003). By comparison, San Juan County had an estimated 242 private nonfarm businesses in 1998, an increase of 22.2 percent over 1990. Table 3–19 provides information on the number and growth of private commercial businesses and farm-based enterprise in the two-county region.

Table 3–19. Commercial and Farm-Based Enterprise in Grand and San Juan Counties

Enterprise	Grand County	San Juan County
Private nonfarm businesses, 1998	360	242
1990–1998 percent change	67.4	22.2
1998 annual payroll per worker	$15,188	$16,464
Percent of national average	49.6	53.8
Percent of Utah average	59.3 (49.6/83.7)	64.3 (53.8/83.7)
1997 accommodation and food service firms	82	38
Paid employees	1,141	382
1997 number of farms	85	231
Land in farms (acres $\times$ 1,000)	76	1,673
1997 value of farm products, average per farm	$26,929	$39,381

Source: U.S. Census Bureau, County and City Data Book: 2000. Percentage of Utah average is calculated by dividing the county annual payroll per employee as a percentage of national average (49.6 percent, 53.8 percent) by the state annual payroll per employee as percentage of national average (83.7 percent).

Signs of a new growth economy are apparent in the service sector, particularly in the number of accommodation and food service firms located in Grand County. In 1997, this sector had 82 firms (mostly located in Moab), supporting 1,141 paid employees. Taxable retail sales, services, and business equipment purchases for Grand County amounted to $159.6 million in 2000 (GPU 2003). Grand County and the city of Moab have experienced significant accommodations growth; lodging capacity increased from 612 rooms to 1,861 rooms (GPU 2003). As a result, the local tax base is heavily dependent on the level of tourism-recreation activity.

By contrast, San Juan County has a much smaller service sector supporting the tourism-recreation-based economy; in 1997, 38 firms provided accommodation and food services and employed 382 workers.

The annual payroll per worker for both Grand County and San Juan County ($15,188 and $16,464, respectively) remained well below state and national averages despite growth and development in the tourism-recreation economy. In Grand County, for example, the annual payroll per worker is only 59.3 percent of the state average and 49.6 percent of the national average. The percentages for San Juan County are somewhat higher than those for Grand County (64.3 percent and 53.8 percent), possibly because its service sector and underlying labor force are less dependent on tourism- and recreation-based activities.

Table 3–19 also provides information on farm-based enterprise in the two-county region. San Juan County had 231 farms in 1997 occupying over 1.6 million acres of land. On average, each farm contributed $39,381 worth of farm products to the local economy, signifying the relative importance of farm-based activity in San Juan's local economy. Farm-based activity in Grand County plays a relatively minor role in its local economy. In 1997, Grand County had 85 farms covering 76,000 acres of land and producing an average value of $26,929 worth of farm products per farm.

The availability of land in Grand County for expanding economic activity is restricted, given the predominant role of state and federal governments in managing nearly 94 percent of Grand County's total land area. For example, only 4.3 percent of the land in Grand County is privately owned; most of the remaining land is managed by the federal government (71.7 percent), owned by the state (15.5 percent), or held in trust as American Indian tribal land (4.4 percent). Other land stakeholders in Grand County include the USFS (1.2 percent) and the U.S. Department of Defense (0.08 percent) (GPU 2003).

3.1.19 Human Health

Human health at and near the Moab site is influenced by the radiation sources in the environment and the contaminants associated with the mill tailings at the site. Exposures occur to occupational workers and members of the public that may live near or recreate adjacent to the site. This section evaluates the potential risks to human health at the Moab site. Appendix D presents a detailed evaluation of the risk to the public.

3.1.19.1 Natural Radiation Environment

Everyone is exposed to three types of ionizing radiation: (1) natural sources unaffected by human activities, (2) those of a natural origin that are affected by human activities, and (3) man-made sources. Natural sources include cosmic radiation from space and naturally occurring radionuclides in soils and rocks. The tailings pile at the Moab site is an example of radiation from a natural origin that has been affected (concentrated) by human activities. Man-made sources include nuclear medicine, medical x-rays, nuclear fallout, and consumer products.

For most of the population, natural background radiation is the largest contributor to their overall radiation dose. The natural occurrence of cosmic radiation and radionuclides at the earth's surface varies throughout the world and depends mostly on the altitude where the exposure occurs and the nearby geology. Cosmic radiation consists of charged particles (primarily extraterrestrial) that generate secondary particles that have direct and indirect ionizing properties. The main radionuclide contributors to external terrestrial gamma radiation are potassium-40 and the members of the thorium and uranium decay series. Impacts (terrestrial gamma and radon gas and its decay products) are mostly from the top several inches of soil.

3.1.19.2 Current Risk to Members of the Public

To evaluate current risk to members of the public, the region of influence is considered to be a 50-mile radius of the Moab site (Figure 3–22). The estimated population in this region is approximately 11,000; most of this population lives within 10 miles of the Moab site.

The majority of the affected population lives in Moab, which is approximately 3 miles from the site. According to the 2000 census, the population of Moab was 4,779. The primary individuals exposed to contaminants at the Moab site are the nearby residents (the closest residents live adjacent to the site approximately 2,200 ft from the tailings pile) and recreational users of land adjacent to the site. Recreational users include Moab residents and tourists. The major recreational activities near the site are rafting on the Colorado River and camping on adjacent lands. Although some minor trespassing has occurred since DOE began managing the Moab site, no members of the public are receiving prolonged exposure to on-site contaminants.

The site contaminants consist of both radioactive and nonradioactive components (e.g., heavy metals). Because members of the public do not have access to the site, essentially all the risks are associated with the radioactive contaminants through exposure to gamma radiation and inhalation of radon gas.

Table 3–20 summarizes the potential dose to members of the public from the radioactive contaminants at the Moab site and from other sources (natural and man-made). This table provides three types of risk numbers. Two sets of numbers are site-related, and the third is an average radiation risk for the U.S. population from natural radiation sources. Site-related risk information is provided for the types of activities that currently occur near the site (rafting and camping) and for the individual who lives closest to the Moab site (the maximally exposed individual). Table 3–20 indicates that the most significant contribution to total dose comes from background sources, not from the Moab site.

Table 3–20. Annual Doses From Background Radiation (Millirem per Year) Compared to Doses From Radon and Gamma Associated With Tailings at the Moab Site

Scenario	Central Tendency[a] (site related)		Background (U.S. average)	Total	RME[b] (site-related)		Background (U.S. average)	Total
	Radon	Gamma			Radon	Gamma		
Camping	15.0	4.0	300	319.0	30.0	7.9	300	337.9
Rafting	7.4	1.6	300	309.0	11.1	2.4	300	313.4
MEI[c]	105.7	16.0	300	421.7	132.3	20.0	300	452.3

Notes: The backup assumptions and calculation sheets are presented in Appendix D.
[a]Central tendency risks are based on more typical exposure assumptions that are still somewhat conservative. Exposure assumptions include the time spent in contaminated areas and the amounts of contaminated material ingested that have a direct impact on the estimated risks.
[b]RME = reasonable maximum exposure.
[c]MEI = maximally exposed individual (the resident closest to the site).

The two types of site-related risks are based on (1) typical exposure assumptions (called central tendency exposures [e.g., amount of contaminated soil accidentally ingested, number of days camping next to the site]), and (2) exposure assumptions that tend to reflect the worst case and result in high-end risks (called reasonable maximum exposures [RMEs]). These high-end risks are based on conservative exposure assumptions resulting in high-end risk estimates. Exposure assumptions include factors such as the number of days spent camping at a site. The site-related exposure doses are based on time spent near the site-related contamination. Details on the assumptions and the calculation approach are presented in Appendix D.

Table 3–20 shows the radiation levels that occur from natural sources such as cosmic rays and natural radioactive materials in the earth. Actual background radiation doses vary with location. In the case of the Moab site, data for Blanding, Utah, were used. The natural background doses assume exposure for an entire year. The *Final Environmental Impact Statement for Remedial Action Standards at Uranium Processing Sites* (EPA 1982) provides more information on the radiation standards.

3.1.19.3 Existing Occupational Risks

DOE contract personnel are on the site Monday through Thursday, except on holidays. On-site personnel conduct maintenance and environmental characterization activities. Maintenance activities include controlling dust using calcium chloride or water spraying, repairing the tailings pile after major precipitation events, and removing process-related material from the site.

Environmental characterization includes collecting samples of soil, ground water, and surface water; conducting gamma surveys of the surface soils; installing ground water monitor wells; conducting land surveys; and conducting vegetation surveys.

Table 3–21 summarizes the 2002 annual personnel exposure report for those employees with a measurable dose.

Table 3–21. 2002 Annual Personnel Exposure Summary Report

Employees with Measured Dose	External Dose (gamma) (mrem/yr)	Internal Dose (whole body from radon) (mrem/yr)	Total Effective Dose Equivalent (mrem/yr)
1	0	31	31
2	0	145	145
3	0	150	150
4	13	60	73
5	10	160	170
6	0	115	116
7	0	567	567
8	13	40	53
9	0	216	216
10	0	186	186
11	13	122	135
Average	**4.5**	**163**	**167**

Eleven other employees that participated in the personnel dose monitors did not have any measurable doses. This table indicates that the most significant dose contribution is from the ingestion of radon gas and that doses to workers vary considerably. All doses are below DOE benchmarks of up to 5,000 millirem per year (mrem/yr).

3.1.20 Environmental Justice

Executive Order 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations* (59 FR 7629), directs federal agencies to identify and address, as appropriate, any activities that may affect minority and low-income populations. A minority has been defined as individual(s) who are members of the following population groups: American Indian or Alaska Native; Asian or Pacific Islander; Black, not of Hispanic origin; or Hispanic. A minority population has been identified where the minority population of the affected area exceeds 50 percent of the population. Low-income populations are groups with an annual income below the poverty threshold.

Table 3–22 presents the minority and low-income populations in Grand and San Juan Counties. A portion of the Uinta and Ouray Indian Reservation is located in northern Grand County. The Ute Mountain (White Mesa Utes) and the Navajo Reservations are situated along the southern border of San Juan County, and American Indians make up the majority of the population in San Juan County: 57 percent of the 14,413 population base. The Hispanic population in Grand County represents the next largest minority population in either of the two counties (5.6 percent).

Table 3–22 also presents the percentage of persons below the poverty line as defined by the U.S. Department of Commerce. San Juan County has a relatively large percentage of individuals below the poverty line (30 percent) compared to Grand County (18 percent). The county poverty trends from 1989 through 1997 show that the percentage of the population falling below the poverty level increased by 34 percent in Grand County and decreased by 10 percent in San Juan County during that time.

Table 3–22. Minority and Low-Income Populations in Grand and San Juan Counties

Population Group	Grand County	San Juan County
2000 population	8,485	14,413
Percent Hispanic or Latino	5.6	3.7
2000 population by race	8,373	14,195
White Non-Hispanic (percent)	7,861 (94%)	5,876 (41%)
Black or African American (percent)	21 (0.3%)	18 (0.1%)
American Indian (percent)	327 (4%)	8,026 (57%)
Some other race (percent)	164 (2%)	275 (2%)
Percent of people below 1997 poverty level	18	30
Percent change 1989–1997	34	–10

Source: 2000 Census

Demographic information obtained from the U.S. Census Bureau was used to identify low-income and minority populations within 50 miles of the Moab site and the proposed off-site alternatives (Klondike Flats, Crescent Junction, and the White Mesa Mill). This radius is consistent with that used to evaluate collective dose for human health effects from the proposed on-site and off-site disposal of the Moab mill tailings and contaminated material from vicinity properties. Census data are compiled at a variety of levels corresponding to geographic areas. In order of decreasing size, the areas used are states, counties, census tracts, block groups, and blocks. A "block" is geographically the smallest census area; it is usually bounded by visible features such as streets or streams or by invisible boundaries such as city limits, township lines, or property boundaries and offers the finest spatial resolution. Block data were used to characterize minority distribution. Because block data are so specific to the individuals within a block (for example, sometimes only one family may live in a block), income data are available only at the block group level and above. For this reason, block group data were used to identify low-income populations.

Demographic maps were prepared using 2000 census data for minority populations and for low-income populations. Figure 3–23 shows census blocks with minority populations that are more than 50 percent within 50 miles. The nearest block occurs about 20 miles south of Moab.

The poverty level established by the Census Bureau for 2000 for a family of four is $18,244. Figure 3–24 shows average household income for the year 2000. Assessment of the census data determined that within the 50-mile area, less than 1 percent of the population had a household income below the poverty level.

3.2 Klondike Flats Site

The proposed Klondike Flats disposal site (Klondike Flats site) is located about 18 miles northwest of the Moab site and just west of US-191. It is remote from populations and behind a low bluff such that the Klondike Flats site is not visible from the highway.

Air quality in this area would be considered similar to and likely better than air quality at the Moab site. There are no major sources of pollutants and no developed industries; regular vehicle use does not occur in the area under consideration. The Moab region is classified as an attainment area under the NAAQS; therefore, the Klondike Flats site is also considered to be an attainment area according to these standards, and air quality is not considered further.